Virginia Unified Risk Assessment Model – VURAM User Guide

For Risk Assessors

Updated June 2020

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I. NOTICE

Virginia DEQ, through its Office of Remediation Programs, funded and managed the project in this User Guide. It has been peer-reviewed by DEQ and approved for publication. Mention of trade names or commercial products does not constitute endorsement or recommendation by DEQ for use. This VURAM User Guide is not intended as regulatory guidance or education. Use of any portion of VURAM in a manner that does not comply with the VURAM User Guide is not recommended.

II. Disclaimer

With respect to the VURAM software and documentation, neither DEQ nor any employee/s assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed. The risk assessment information provided in this manual reflects the application of risk assessment to various programs at Virginia DEQ. Use of VURAM assumes familiarity with the regulatory programs discussed herein. The VURAM User Guide is not intended to provide regulatory guidance or education. Furthermore, software and documentation are supplied "as-is" without guarantee or warranty, expressed or implied, including without limitation, any warranty of merchantability or fitness for a specific purpose.

III. Acknowledgments

We wish to express our gratitude and thanks to our friends and colleagues who contributed to the development of VURAM. We wish to especially acknowledge the Virginia DEQ risk assessors Patricia McMurray, Sonal Iyer, Kyle Newman, and Vrushali Gandhi, and the technical contributions of April Ni'Mary, Allyson Lackey, Arianna Johns, and Hope Pelka. Special thanks to Justin Williams, Chris Evans, and Bob Nicholas of DEQ, whose support made the development of VURAM possible. Also thanks to the staff of PIONEER Technologies Corp. and TechLaw, and our colleagues at Virginia DEQ, EPA, and Oak Ridge National Laboratories (ORNL) for testing, review, and support in the development of VURAM and its associated documentation.

IV. Contacts Table

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1.0 Virginia Unified Risk Assessment Model (VURAM)

VURAM is a mathematical database model developed in Microsoft Access and made available through the Virginia DEQ Central Office in Richmond, Virginia. The model utilizes four interrelated baseline risk assessment concepts: data analysis, exposure assessment, toxicity assessment, and risk characterization, to estimate the potential risk (cancer and non-cancer) from exposure to contaminated media. VURAM assumes that a site contaminated with hazardous substances has been identified and investigated, resulting in a full site characterization, including an evaluation of contaminant fate and transport, with data quality objectives and assessment. In order to ensure that risk is not underestimated, several assumptions in both the screening and quantitative risk assessment modules utilize a more conservative approach in order to ensure that the study area population is not exposed to unacceptable risk level. Reasonable maximum exposure or reasonable worst case exposure scenarios are always employed. Refer to RAGS Part A for more information.

1.1 Software Requirements

VURAM is a database model developed using Visual Basic for Applications under Microsoft Access 2007/2010 and is run as a Microsoft Windows application within Microsoft Access 2007 or later.

ALERT! Force quitting MS Access while VURAM is open can cause database corruption. Wait for MS Access to completely close before attempting any actions, including re-opening, on the VURAM file.

ALERT! For stable performance, always run VURAM from a local drive. Network or shared drive locations can impair database performance or cause the program calculations to fail.

IMPORTANT! The current available version of VURAM supersedes all previous versions. Visit Virginia DEQ's Risk Assessment website for the latest version.

1.2 User Guide

This User Guide serves as a comprehensive reference for use of VURAM that documents the risk assessment and modeling approach incorporated in VURAM. Refer to the EPA Regional Screening Level (RSL) website, EPA exposure factors Handbook: 2011 Edition, EPA Superfund Soil Screening Guidance, and Superfund Risk Assessment for supplemental information concerning the parameters and assumptions incorporated in VURAM. This document does not establish binding rules, but provides a recommended risk assessment process that incorporates risk assessment methodology described in RAGS Part A through E and EPA RSL Guidance. The report outputs from VURAM provide the information required in RAGS Part D tables. Alternative approaches for risk assessment may be determined to be more appropriate at sites where specific circumstances do not match the underlying assumptions, conditions, and models of this tool. The parameters and equations provided in appendix A1.0. and appendix A2.0 are available for calculating hazard/risk for site-specific information, provided such approach has been documented, discussed, and approved by Virginia DEQ for facilities in Virginia.

IMPORTANT! VURAM and User Guide are not a risk assessment training or education resource. The use of the tables or calculated results in this manual are at the sole discretion of the user and the understanding of the assumptions incorporated in these results, as well as the appropriate application of the same, is the responsibility of the individual using VURAM.

1.3 Recommended Use

For facilities in Virginia under the Resource Conservation and Recovery Act (RCRA) (both: Permit Facilities and Corrective Action), the Virginia Voluntary Remediation Program (VRP), the Virginia Brownfields Program, and the Virginia Solid Waste Management Regulations (VSWMR), VURAM is the recommended risk assessment tool to support risk-based evaluations. Use of VURAM and VURAM User Guide assumes familiarity with the regulatory programs discussed herein.

IMPORTANT! Perform risk assessments in accordance with project specific agreements and work plans approved by Virginia DEQ project manager.

1.4 Model Limitations

The risk assessment information provided in this manual reflects the manner in which selected programs at Virginia DEQ apply risk assessments to program-specific needs. All calculated hazard/risk values are site-specific and for human receptors. The risk assessment process acknowledges that contaminant data and other site-related information is usually limited and that only a small sampling of site-representative data are available to make human health and ecological risk decisions. This means risk assessors often have to make estimates and exercise professional judgment when performing risk calculations. Consequently, all risk estimates have a certain degree of uncertainty. For this reason, a key part of risk assessment is an open presentation of the uncertainties in the calculations and a characterization of how reliable, or unreliable, the resulting risk estimates truly are. Uncertainty is present and inherent throughout the modeling process. Model uncertainty arises from a lack of knowledge about natural processes, simplifying assumptions in mathematical formulations and associated parameters, and/or data coverage and quality.

The evaluation of appropriateness, representativeness, and qualification of analytical data generated during investigation is not incorporated into VURAM. Consult RAGS Part A for data qualifiers and the use in risk assessment. Data with no qualifiers can be used in the quantitative risk assessment module without issue. However, data with qualifiers should be discussed with DEQ project manager or risk assessor before continuing to quantitative risk assessment. Based on overall data density and quality, other qualifiers may also be included in risk assessment.

Hazard/risk calculations in VURAM do not consider ecological risk assessment. If the CSM indicates potential exposures to ecological receptors, a separate ecological risk assessment must be performed. The calculated acceptable goal obtained from VURAM may be used to evaluate potential ecological risk to ensure that the chosen remediation/cleanup goals are protective of ecological receptors. Refer to the following for more information on conducting ecological risk assessments:

- Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments - Interim Final (EPA)
- Guidelines for Ecological Risk Assessment (EPA)
- Ecological Soil Screening Levels (Eco-SSL) Guidance and Documents (EPA)

Evaluation for lead exposure is **NOT** included in the quantitative risk assessment module of VURAM. If lead is a COPC, refer to EPA's Lead at Superfund Sites: Software and Users Manual (EPA, 2017a) and run the Integrated Exposure Uptake Biokentic (IEUBK) model and Adult Lead Methodology (ALM) model.

IMPORTANT! VURAM does **NOT** include tools for developing a conceptual site model (CSM), algorithms to calculate uncertainties, statistical analysis for Upper Confidence Limit (UCL)/Upper Tolerance Limit (UTL), probabilistic risk assessment, fate and transport modeling, quantitative evaluation of lead, or quantitative risk assessment for ecological receptors.

1.5 Prerequisites for Computation

Users should be knowledgeable in the science and terminology of risk assessment, data quality objectives, data quality assurance plans, exposure assessment, and toxicity assessment. Reliable results from VURAM depend on the quality of the data and information entered into the calculations. Therefore, valid and reliable input data are necessary to ensure accuracy. Incomplete or inaccurate data will yield results with a high degree of uncertainty.

IMPORTANT! The current available version of VURAM supersedes all previous versions. Confirm the latest version of VURAM before conducting risk assessment. Updates to VURAM follow the EPA RSL semi-annual update schedule. Visit Virginia DEQ's Risk Assessment website for the latest version.

1.5.1 Conceptual Site Model (CSM)

The CSM should consider the nature of the contamination, the lateral and vertical extent of contamination, fate and transport of contaminants, subsurface geology and hydrogeology, surface waters, and preferential pathways of contaminant migration, as well as potential ecological and human receptors, demographics, land use (past, present, and future), and other relevant information. Each step of the risk assessment is determined by the CSM for site-specific conditions. Decisions must be evaluated against the CSM for accurate application of the calculated hazard/risk. The evaluation and assessment of different exposure areas (onsite vs. offsite) or different land use scenarios (current vs. future) may require the development of separate CSMs.

The foundation of the CSM is the site characterization, which identifies and characterizes the presence and extent of hazardous substances at a site and any associated threat to human health and the environment. A thorough and complete site characterization must be performed to obtain the site-specific data required for risk assessment input parameters. The site characterization process should investigate the saturated and unsaturated zones, surface and subsurface soil, unfiltered groundwater, unfiltered surface water, sediments, subsurface geology and hydrogeology, air (ambient air, soil gas, sub-slab gas, and indoor air). **IMPORTANT!** The CSM is the basis for data determining site-specific risk-based cleanup goals. The quantitative risk assessment module in VURAM relies on inputs matching the CSM to generate an applicable risk assessment. Refer to RAGS Part A (EPA) and the Superfund Soil Screening Guidance for Superfund: Users Guide (EPA) for more information on developing a CSM.

1.5.2 Fate and Transport

The CSM must account for all variables that influence the fate and transport of contaminants, in order to produce a viable simulation of the present extent of contamination and prediction of future conditions. Relevant fate and transport processes include the movement of chemical contaminants from soil to groundwater, soil to surface water, groundwater to surface water, soil/groundwater to soil gas/air, groundwater to shower air, and soil gas/sub-slab gas to indoor air. Fate and transport modeling is not included in VURAM. However, if contamination is expected to reach groundwater and/or surface water within 30 years, then fate and transport model-based estimates of groundwater/surface water contaminant concentration/s can be entered into the risk assessment portion of VURAM to assess whether the predicted concentration/s will be within acceptable hazard/risk levels. If estimated concentrations fail acceptable hazard/risk levels, then acceptable concentrations may need to be revised accordingly. For further information on fate and transport evaluations, refer to the Superfund Exposure Assessment Manual (EPA).

IMPORTANT! For soil and groundwater, as applicable, recommended acceptable concentrations must be evaluated with respect to contaminant's fate and transport. VURAM does **NOT** perform fate and transport modeling.

1.5.3 Sampling

Proper sampling and analysis of all potentially contaminated media, including unfiltered groundwater, unfiltered surface waters, surface and subsurface soils, sediments, air (ambient, sub-slab gas, soil gas, and indoor air), wastes and sludge, and food for a wide range of compounds is necessary to produce validated data. More than one round of sampling data may be needed for thorough site characterization. Further information provided by EPA on the quality of data appropriate for risk assessment and modeling is available from the following:

- Guidance for Data Usability in Risk Assessment Final Part A
- Data Quality Objectives for Remedial Response Activities
- Soil Screening Guidance: Technical Background Document
- Risk Assessment Guidance for Superfund, Volume I - Human Health Evaluation Manual (Part A)
- OSWER Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils, Appendix E (Subsurface Vapor Intrusion Guidance)
- Vapor Intrusion Pathway: A Practical Guidance

Statistical analysis is an integral part of risk assessment data evaluation. Virginia DEQ recommends using EPA's Statistical Software ProUCL for statistical analysis. Refer to the following resources for more information on sampling and statistical evaluation approach:

- Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities Unified Guidance
- ProUCL User Guide: Statistical Software for Environmental Applications for Data Sets with and without Nondetect Observations
- Chemical Concentration Data near the Detection Limit
- Risk Assessment Guidance for Superfund: Volume I - Parts A, B, C, D, E, and F

2.0 Running VURAM

Open VURAM by double-clicking on the database file or by selecting the file from the Open option in MS Access. The database file must be from a trusted location or identified as a trusted document in MS Access in order to run. If VURAM does not auto-start, refer to the FAQ section 2.10.1 to begin.

A series of interactive form pages for selecting chemicals, study area, media, and receptor parameters guide the risk assessment process in VURAM. After all site-specific selections and inputs are complete, VURAM calculates outputs, which are provided through a series of printable reports for each evaluated chemical by exposure pathway and media. The Chemical Abstract Service Registry Number (CAS RN or CAS) is a unique chemical identification number for each chemical included in VURAM. In cases where no CAS RN is available, an EPA identification number (E#) or a DEQ assigned CAS substitute identifies the chemical. Refer to appendix A3.8 for a complete list of these chemicals.

IMPORTANT! Complete a thorough Conceptual Site Model (CSM) before running VURAM. The CSM determines all applicable model parameters and is key to reliable computation.

After completing a screening levels risk assessment and/or interim action, assess COPCs that fail screening and/or remain after performing interim action using quantitative risk assessment. The data quality objectives and the CSM for hazard/risk calculations may be different from the initial or preliminary site investigations (e.g., RCRA Facility Investigation Phase I). Therefore, the quantity and quality of data needed may differ from the existing and available data.

IMPORTANT! If the information is incomplete, the site must be reassessed for the necessary data before evaluating quantitative risk in VURAM. This can include additional sampling, data collection, and/or statistical analysis.

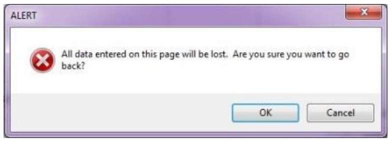
Information icons, warning and instruction messages, and other indicators are included in VURAM to help guide the risk assessment process. Pop-up message windows and indicator icons appear when errors have occurred, actions have been completed, or further action is required.

Green Check Mark: Displayed with the label for a selected environmental medium to indicate that the calculation, screening, or comparison is complete.

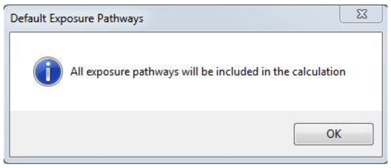
Gray Information Triangle: Displayed with the Page Is Not Available label in the quantitative risk assessment module where a selected environmental medium is not available for calculation based on the program or study area.

Red X: Displayed next to the section on a page where inputs or selections are required before proceeding with the next steps in VURAM. Check all environmental media tabs for the red X indicator if unable to proceed in VURAM.

Blue Information Circle: Interactive icon can be clicked to provide additional information for a page section or selection.



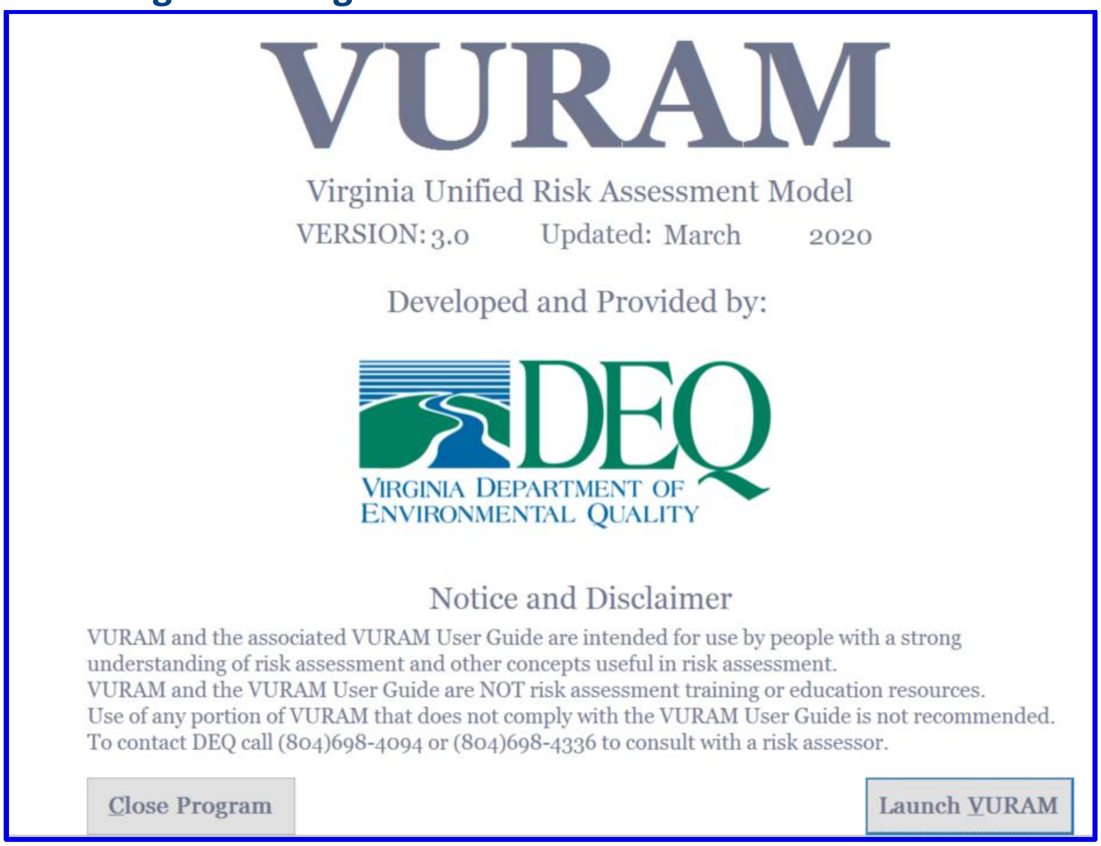
Alert Message: Contains important information about proceeding with VURAM. A cancel option is provided when data loss can occur such as selecting Go Back or Quit on each page.



Information Message: Displayed when selecting the blue information icon. Contains important information on the risk assessment process or program parameters.

IMPORTANT! Individual model runs of VURAM are site-specific. All images in this User Guide are for demonstration only and do not represent any actual site data or analysis.

2.1 Background Page



Once VURAM is open, the background page will remain open throughout the session.

Notice and Disclaimer: VURAM and the associated VURAM User Guide are intended for use by people with a strong understanding of risk assessment and related concepts. VURAM and the VURAM User Guide are NOT risk assessment training or an educational resource. Any use of VURAM that does not comply with the VURAM User Guide is not recommended. To consult with a DEQ risk assessor, call (804) 698-4094 or (804) 698-4336.

To continue with VURAM, select the Launch VURAM button. Subsequent pages will open and close based on the selected program modules. On all subsequent pages, the Quit button will end the VURAM session and return to this background page. To close VURAM, select the Close Program button or close MS Access through the navigation menu icons in the top right hand corner of the application.

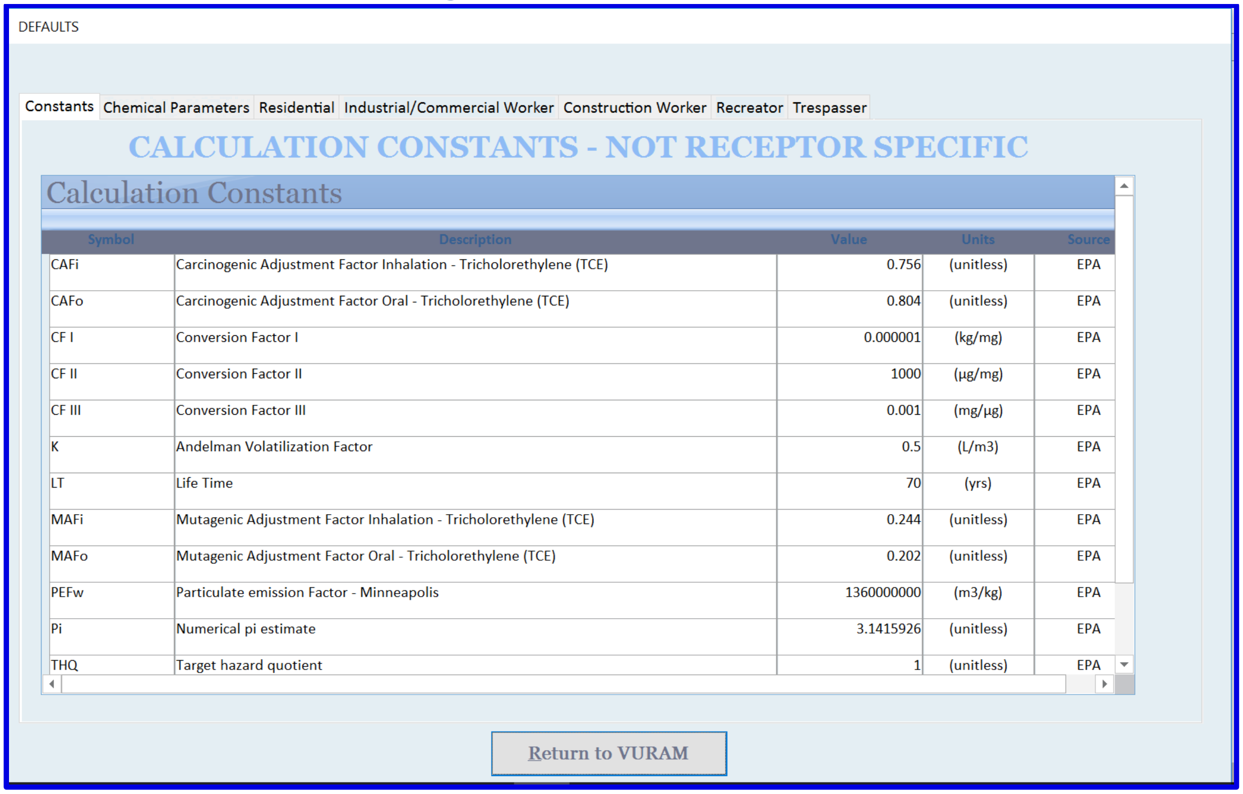
IMPORTANT! The current available version of VURAM supersedes all previous versions. Confirm the latest version of VURAM before conducting risk assessment. Updates to VURAM follow the EPA RSL semi-annual update schedule. Visit Virginia DEQ's Risk Assessment website for the latest version.

2.2 Introduction Page

The introduction page provides entry into the three modules of VURAM via the buttons located under the Virginia DEQ logo. To review the values used in all risk computations, click the View Standard Defaults button, see section 2.3 for details. To Quit VURAM and return to the background page, click Quit.

Make the appropriate module selection and proceed to the associated User Guide section to continue: Screening Levels, section 2.5, Quantitative Risk Assessment, section 2.7, or Site-Specific Background Comparison, section 2.9.

2.3 Standard Defaults Page



DEFAULTS

Constants | Chemical Parameters | Residential | Industrial/Commercial Worker | Construction Worker | Recreator | Trespasser

CALCULATION CONSTANTS - NOT RECEPTOR SPECIFIC

Calculation Constants

Symbol	Description	Value	Units	Source
CAFi	Carcinogenic Adjustment Factor Inhalation - Tricholorethylene (TCE)	0.756	(unitless)	EPA
CAFo	Carcinogenic Adjustment Factor Oral - Tricholorethylene (TCE)	0.804	(unitless)	EPA
CF I	Conversion Factor I	0.000001	(kg/mg)	EPA
CF II	Conversion Factor II	1000	(µg/mg)	EPA
CF III	Conversion Factor III	0.001	(mg/µg)	EPA
K	Andelman Volatilization Factor	0.5	(L/m3)	EPA
LT	Life Time	70	(yrs)	EPA
MAFi	Mutagenic Adjustment Factor Inhalation - Tricholorethylene (TCE)	0.244	(unitless)	EPA
MAFo	Mutagenic Adjustment Factor Oral - Tricholorethylene (TCE)	0.202	(unitless)	EPA
PEFw	Particulate emission Factor - Minneapolis	1360000000	(m3/kg)	EPA
Pi	Numerical pi estimate	3.1415926	(unitless)	EPA
THQ	Target hazard quotient	1	(unitless)	EPA

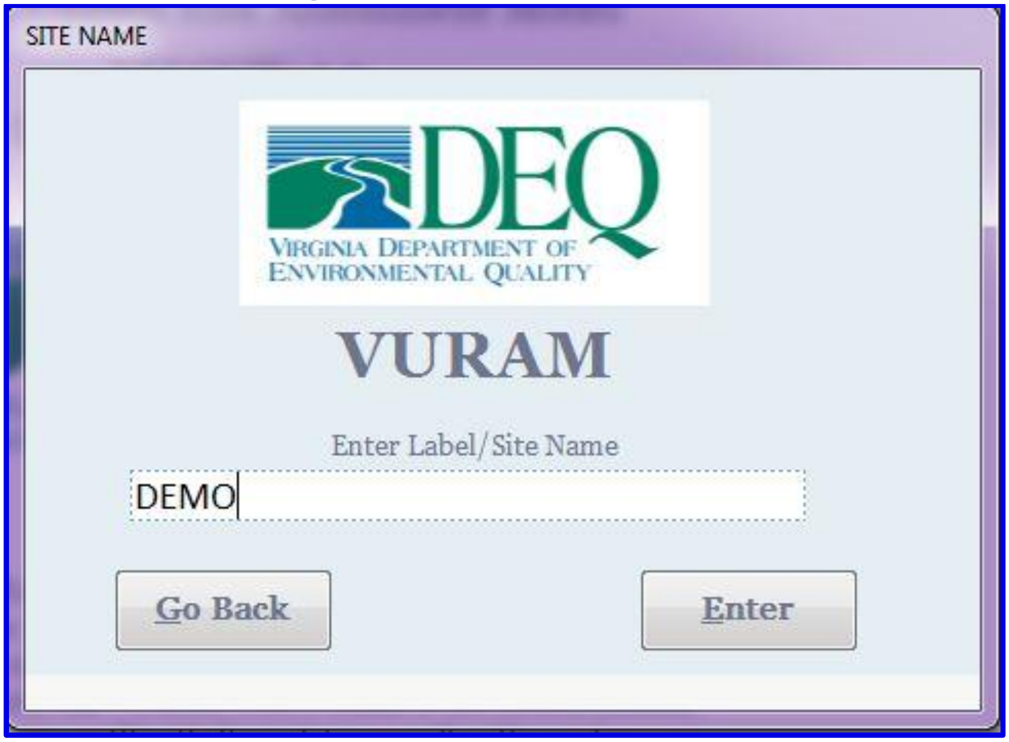
Return to VURAM

The standard defaults page provides a series of tables navigable through the tab controls at the top of the page: Constants, Chemical Parameters, Age-segment Values, Residential, Industrial/Commercial Worker, Construction Worker, Recreator, and Trespasser. Tables on each tab page include the symbol used in the equations, a description of the parameter, the numeric value, and units for each term. Complete values tables and calculation equations are available in appendix A1.0 and appendix A2.0. Values are from EPA RSL where available; the description field contains the text "Virginia DEQ" for non-RSL values.

For Chemical Parameters, numeric values are not included. To view chemical specific values, see the Setup Page of the appropriate VURAM module. Click Return to VURAM to continue.

IMPORTANT! Standard defaults are for reference only. VURAM does not allow editing of default values or chemical parameters.

2.4 Site Name Page



The Site Name page requires a text entry to identify the site throughout the module and on the output report. The input is limited to 50 characters. Click Enter to proceed to selected VURAM module or Go Back to return to the Introduction Page.

2.5 Screening Levels Module

The screening levels presented in this module incorporate EPA Region III Regional Screening levels (RSLs) and Virginia DEQ program-specific nuances. They are risk-based concentrations derived from standaridized equations combining exposure information assumptions with EPA toxicty data. They are not de facto clean up standards, however can help to identify areas, contaminants and conditions that require further investigation at a particular site.

IMPORTANT! Chemicals listed as Not Evaluated (NE) should not be excluded from the quantitative risk assessment. Such chemicals should at least be discussed in the uncertainty analysis.

All complete exposure pathways require further evaluation unless there is sound justification (e.g., based on the results of a screening analysis) to eliminate a pathway from detailed analysis. If a pathway is excluded from further analysis, clear documentation for the decision is required in the exposure assessment section of the risk assessment report. Generally, at sites where contaminant concentrations fall below screening levels, no further action or study is warranted, provided the exposure assumptions at a site match those taken into account by the screening calculations. COPC concentrations above the screening level do not automatically designate a site as contaminated or trigger a response action. However, exceeding a screening value suggests that further evaluation of the potential risks is appropriate.

Screening values can also be a useful tool for identifying initial cleanup goals and could provide long-term targets to use during the analysis of remedial options. By developing screening levels early in the decision making process, the remediation team may be able to streamline the consideration of remedial alternatives. Sites applying for closure of permitted facilities under RCRA, using risk-based cleanup goals that also pose imminent and substantial endangerment to human health and the environment, may implement the EPA RSL residential values, or other interim cleanup guidance as approved by Virginia DEQ, as interim cleanup goals.

2.5.1 Screening Criteria

Two regulatory programs are available in the screening levels module of VURAM 1) RCRA Corrective Action, section 2.5.1d and 2) Voluntary Remediation Programs (VRP), section 2.5.1e. While the general approach to developing screening levels is consistent, some programmatic differences exist. VURAM provides screening levels for the following environmental media: soil, groundwater, air, surface water, and sediment. For each chemical, VURAM compares concentration inputs against screening value in all applicable media simultaneously. The screening report, section 2.5.5, identifies the contaminants of potential concern (COPCs) that exceed screening values by environmental medium and screening type.

IMPORTANT! Once a regulatory program is established, screening may require re-evaluation under the appropriate program. Contact the Virginia DEQ Project Manager for further input.

In general, risk-based screening level values for a given program are generated in two steps by (1) identifying the contaminant concentrations that correspond to the program-specific target risk (TR) and target hazard quotient (THQ) and (2) selecting the lower of these concentrations as the screening level. Program-specific guidelines consider other screening criteria in determining screening values for some screening types. Under both RCRA Corrective Action and VRP the THQ is 0.1, to allow for the potential additive toxicity of multiple contaminants. The risk threshold for carcinogens is 10^{-6} in RCRA Corrective Action and 10^{-5} in the VRP.

IMPORTANT! For screening, use of maximum concentration for each medium as the exposure concentration for a given pathway is recommended, to place an upper bound on exposure (RAGS Part A). For non-detects, use ½ of the method detection limit. In cases where the method detection limit exceeds screening values contact the Virginia DEQ project manager and/or risk assessor.

NOTE: The current RSL screening value for lead in soils is 400 mg/kg for residential and 800 mg/kg for industrial.

IMPORTANT! In absence of speciation data, assume all chromium concentrations to be in hexavalent form, chromium VI, CAS 18540-29-9.

2.5.1a Maximum Contaminant Levels (MCLs)

EPA promulgates Maximum Contaminant Levels (MCLs) established by the Safe Drinking Water Act and the National Primary Drinking Water Regulations. MCLs are promulgated by EPA for use by public water systems to protect public health by limiting the levels of contaminants in drinking water. MCLs are not intended as risk-based screening criteria. Therefore, if a chemical concentration in water is below the published MCL but it is identified as a risk driver, reduction in concentration may be required to meet risk-based criteria.

IMPORTANT! Individual trihalomethanes(THMs) and haloacetic acids (HAAs) have a listed MCL which is applicable to total constituent concentrations. See appendix A3.1 chemical notes.

2.5.1b Vapor Intrusion (VI)

For Vapor Intrusion (VI) screening of groundwater and air media, only chemicals identified as a volatile organic compound (VOC) in the RSL table are included in the screening calculations. VI evaluations rely on multiple lines of evidence. For more information on developing multiple lines of evidence and vapor intrusion methodologies, consult OSWER Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Sources to Indoor Air , Vapor Intrusion Pathway: A Practical Guideline, and Vapor Intrusion Pathway: Investigative Approaches for Typical Scenarios (A Supplement to VI-1).

If site-related volatile chemicals are present in soil and/or groundwater, Virginia DEQ recommends the collection of sub-slab/shallow soil gas in any potentially affected buildings, along with deep soil gas samples. Deep soil gas samples are those collected above the capillary fringe and not less than 5 feet below the surface. It is preferred that deep soil gas samples be collected at a depth of at least 10 feet unless the capillary fringe is shallower. Deep or shallow soil gas data can be used to screen for construction worker soil gas. Refer to A2.5: Construction Worker Trench Model: Soil Gas for a detailed review.

IMPORTANT! If groundwater, soil, and/or any soil gas data are above screening criteria then a detailed site-specific VI evaluation may be necessary. Contact Virginia DEQ project manager and risk assessor for further discussions of screening results or VI.

IMPORTANT! The inhalation pathway and VI scenarios for mercury use screening levels for elemental mercury, CAS 7439-97-6.

2.5.1c Surface Water and Sediment

Surface water screening values derive from EPA's National Recommended Water Quality Criteria tables (EPA, 2017) for Human Health (HH) and Aquatic Life, as well as Virginia Water Quality Standards (VAWQS) Criteria for Surface Water table 9VAC25-260-140. For VRP screening, Virginia Water Quality Standards (WQS) are chosen first over the Federal National Recommended Water Quality Criteria and RCRA Corrective Action its vice versa. Surface water screening values are unique to Virginia DEQ and are **NOT** computed using the EPA RSL recreator equations and parameters.

Sediment screening applies only to the VRP. Screening values are **NOT** computed using the recreator equations. Rather, the residential soil screening level is multiplied by 10 to provide the sediment screening value in the screening levels module.

IMPORTANT! Include surface water screening for sites with surface water and/or sediment on the site or adjacent to the site. Consult RCRA risk assessment guidance for more details (EPA, 1989-2017).

IMPORTANT! Surface water and sediment screening values are human health-based and are **NOT** applicable to ecological endpoints.

IMPORTANT! For surface water screening methylmercury, CAS 22967-92-6, concentrations are in mg/kg instead of µg/L. This fish tissue residue criterion for methylmercury is based on a total fish consumption rate of 0.0175 kg/day.

2.5.1d RCRA Corrective Action

Evaluation is required for residential and composite industrial land use scenarios and must address cross-media transfer, which includes soil-to-groundwater and groundwater-to-air at a minimum and includes ecological risk when necessary. The standard list of analytes for RCRA Corrective Action facilities is from the list of Hazardous Constituents in Appendix VIII of Part 261 for soils and from the list of Hazardous Constituents in Appendix IX of Part 264 for groundwater. This list may be reduced in some cases if the site history is well known. Site-specific constituents not included in either Appendix VIII or IX may also need to be included. Discuss the analyte list with the project manager and risk assessor before developing the sampling plan.

NOTE: Calculations for RCRA Corrective Action Screening follow the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), also known as Superfund, risk assessment paradigm. Use RCRA Corrective Action if conducting screening evaluation for CERCLA, Federal Facilities, or Solid Waste Vapor Intrusion (VI) sites.

IMPORTANT! MCLs are not risk-based values and are included in RCRA for reference only.

IMPORTANT! Consult residential groundwater and soil screening level (SSL), Risk-Based SSL (DAF1), results to evaluate the soil-to-groundwater pathway. Additional modeling and/or groundwater monitoring may be required before conducting quantitative risk assessment for groundwater exposure.

Table 2.5.1d-1 RCRA Soil Screening (mg/kg)

Screening Type	Screening Criteria	Notes
Residential Soil	Lower of Residential Soil (TR = 1E-6 and Child HQ = 0.1)	Same as EPA RSL table
Industrial Soil	Lower of Industrial Soil (TR = 1E-6 and HQ = 0.1)	Same as EPA RSL table
Risk-based SSL	Lower of Residential Tapwater (TR = 1E-6 and Child HQ = 0.1) * DAF1	Same as EPA RSL table DAF1 equation: appendix A1.7
MCL-based SSL	MCL * DAF1	Same as EPA RSL table DAF1 equation appendix A1.7 For reference only; MCLs are not risk-based values

Table 2.5.1d-2 RCRA Groundwater Screening (µg/L)

Screening Type	Screening Criteria	Notes
Residential Tapwater	Lower of Residential Tapwater (TR = 1E-6 and Child HQ = 0.1)	Same as EPA RSL table
MCL	Promulgated by EPA	Same as EPA RSL table For reference only; MCLs are not risk-based values
Residential Groundwater VI	Calculated on Residential Indoor Air Screening Level	Groundwater Vapor Intrusion (VI) equation appendix A1.6 Computed for VOCs only
Industrial Groundwater VI	Calculated on Industrial Indoor Air Screening Level	Groundwater Vapor Intrusion (VI) equation appendix A1.6 Computed for VOCs only

Screening Type	Screening Criteria	Notes
Construction Worker Groundwater Direct/Indirect Contact	Calculated on Virginia DEQ Construction Worker Trench Model	Construction Worker Trench Model appendix A2.1 Contact based on groundwater depth. Direct Contact: dermal, ingestion, and inhalation pathways Indirect Contact: inhalation only Inhalation computed for VOCs only

Table 2.5.1d-3 RCRA Air Screening (µg/m³)

Screening Type	Screening Criteria	Notes
Residential Indoor Air	Lower of Residential Air (TR = 1E-6 and Child HQ = 0.1)	Same as RSL table Same as Residential Ambient Air
Residential Ambient Air	Lower of Residential Air (TR = 1E-6 and HQ = 0.1)	Same as EPA RSL table Same as Residential Indoor Air
Residential Shallow/Sub-Slab Soil Gas	Residential Indoor Air/0.03	Computed for VOCs only
Residential Deep Soil Gas	Residential Indoor Air/0.01	Computed for VOCs only
Industrial Indoor Air	Lower of Industrial Air (TR = 1E-6 and HQ = 0.1)	Same as EPA RSL table Same as Industrial Ambient Air
Industrial Ambient Air	Lower of Industrial Air (TR = 1E-6 and HQ = 0.1)	Same as Industrial Indoor Air
Industrial Shallow/Sub-Slab Soil Gas	Industrial Indoor Air/0.03	Computed for VOCs only
Industrial Deep Soil Gas	Industrial Indoor Air/0.01	Computed for VOCs only
Construction Worker Soil Gas	Calculated on Virginia DEQ Construction Worker Trench Model	Computed for VOCs only Construction Worker Trench Model appendix A2.2

Table 2.5.1d-4 RCRA Surface Water Screening (µg/L)

Screening Type	Screening Criteria	Notes
Surface Water Fresh	Lower of (Fed HH-Water + Organism, VAWQS-HH-PWS). If no value present, used MCL.	From National Recommended Water Quality Criteria and VAWQS Tables Methylmercury, CAS 22967-92-6; concentrations in (mg/kg)
Surface Water Marine	Lower of (Fed HH-Organism Only, VAWQS-HH-OSW). If no value present, used MCL.	From National Recommended Water Quality Criteria and VAWQS Tables Methyl mercury CAS 22967-92-6; concentrations in mg/kg

2.5.1e Voluntary Remediation Program (VRP)

There are three tiers for evaluation and screening in VRP:

Tier I Site-specific Background

Tier II Unrestricted/Residential

Tier III Restricted/Commercial/Industrial (Construction Worker included in Tier III)

If all concentrations in all media are less than the Tier I background levels and/or Tier II screening levels then no further risk assessment is required. Refer to DEQ's VRP Risk Assessment Guidance to obtain detailed information on how to conduct screening at VRP and Brownfields sites.

NOTE: Use VRP screening to evaluate Virginia Brownfields Land Renewal Program.

IMPORTANT! Do not exclude metals from screening or prior to conducting Tier I screening. Provide the Site-specific Background Comparison Report, section 2.9.2, for chemicals eliminated from quantitative risk assessment based on Tier I background levels.

IMPORTANT! If Total Petroleum Hydrocarbon (TPH) levels in soil samples are more than 100 ppm, analyze soil and groundwater samples for Target Analyte List (TAL) metals, volatile organic compounds (VOCs) and semi-volatile organic compounds (SVOCs).

If COPC concentrations exceed the screening levels, the participant may proceed to the site-specific quantitative risk assessment. For COPCs that exceed Tier II screening levels, participants may choose to perform Tier III screening based on the receptors of concern and the proposed restrictions for the site. Tier II levels for soil and groundwater assume residential exposure. However, sites such as schools, day care centers, hospitals, nursing homes, parks, and agricultural areas are considered as Tier II Unrestricted for screening purposes.

Tier III screening is only for sites that adopt one or more formal use restrictions, such as agroundwater use restrictions, a vapor mitigation requirement, a prohibition of digging or construction, a health and safety plan requirement, etc. Soil Screening Levels (SSLs) for contaminant migration to groundwater are not included in Rier III screening. For more information on offsite plume migration, characterization, and use restrictions for groundwater, refer the VRP Risk Assessment Guidance. Evaluation of groundwater contaminant migration to indoor air (VI) requires a separate evaluation.

IMPORTANT! Unrestricted use sites include residential use, schools, day care centers, hospitals, nursing homes, parks, and agricultural areas.

IMPORTANT! Tier III **DOES NOT** apply to unrestricted-use sites. Consult VRP project manager and risk assessor to determine whether Tier III screening is appropriate for a particular site.

Table 2.5.1e-1 VRP Soil Screening (mg/kg)

Screening Type	Screening Criteria	Notes
Residential Soil Tier II	Lower of Residential Soil (TR = 1E-5 and Child HQ = 0.1), and SSL-DAF20	DAF20 equation: appendix A1.7 SSL-DAF20 = VRP Tapwater Tier II ×DAF20

Screening Type	Screening Criteria	Notes
Industrial Soil Tier III	Lower of Industrial Soil (TR = 1E-5 and HQ = 0.1)	n/a

Table 2.5.1e-2 VRP Groundwater Screening (µg/L)

Screening Type	Screening Criteria	Notes
Residential Tapwater Tier II	MCL if available, or Lower of Residential Tapwater (TR = 1E-5 and Child HQ = 0.1)	Virginia DEQ VRP Policy Decision
Residential Groundwater VI Tier III	Calculated on Residential Indoor Air Screening Level	Groundwater Vapor Intrusion (VI) equation appendix A1.6 Computed for VOCs only
Industrial Groundwater VI Tier III	Calculated on Industrial Indoor Air Screening Level	Groundwater Vapor Intrusion (VI) equation appendix A1.6 Computed for VOCs only
Construction Worker Groundwater Tier III Direct/Indirect Contact	Calculated on Virginia DEQ Construction Worker Trench Model	Construction Worker Trench Model appendix A2.1 Contact based on groundwater depth. Direct Contact: dermal, ingestion, and inhalation pathways Indirect Contact: inhalation only Inhalation computed for VOCs only

Table 2.5.1e-3 VRP Air Screening (µg/m³)

Screening Type	Screening Criteria	Notes
Residential Indoor Air Tier III	Lower of Residential Air (TR = 1E-5 and Child HQ = 0.1)	Same as Residential Ambient Air Tier III
Residential Ambient Air Tier III	Lower of Residential Air (TR = 1E-5 and HQ = 0.1)	Same as Residential Indoor Air Tier III
Residential Shallow/Sub-Slab Soil Gas Tier III	Residential Indoor Air Tier III/0.03	Computed for VOCs only
Residential Deep Soil Gas Tier III	Residential Indoor Air Tier III/0.01	Computed for VOCs only
Industrial Indoor Air Tier III	Lower of Industrial Air (TR = 1E-5 and HQ = 0.1)	Same as Industrial Ambient Air Tier III
Industrial Ambient Air Tier III	Lower of Industrial Air (TR = 1E-5 and HQ = 0.1)	Same as Industrial Indoor Air Tier III
Industrial Shallow/Sub-Slab Soil Gas Tier III	Industrial Indoor Air Tier III/0.03	Computed for VOCs only
Industrial Deep Soil Gas Tier III	Industrial Indoor Air Tier III/0.01	Computed for VOCs only

Screening Type	Screening Criteria	Notes
Construction Worker Soil Gas Tier III	Calculated on Virginia DEQ Construction Worker Trench Model	Computed for VOCs only Construction Worker Trench Model appendix A2.2

Table 2.5.1e-4 VRP Surface Water Screening (µg/L)

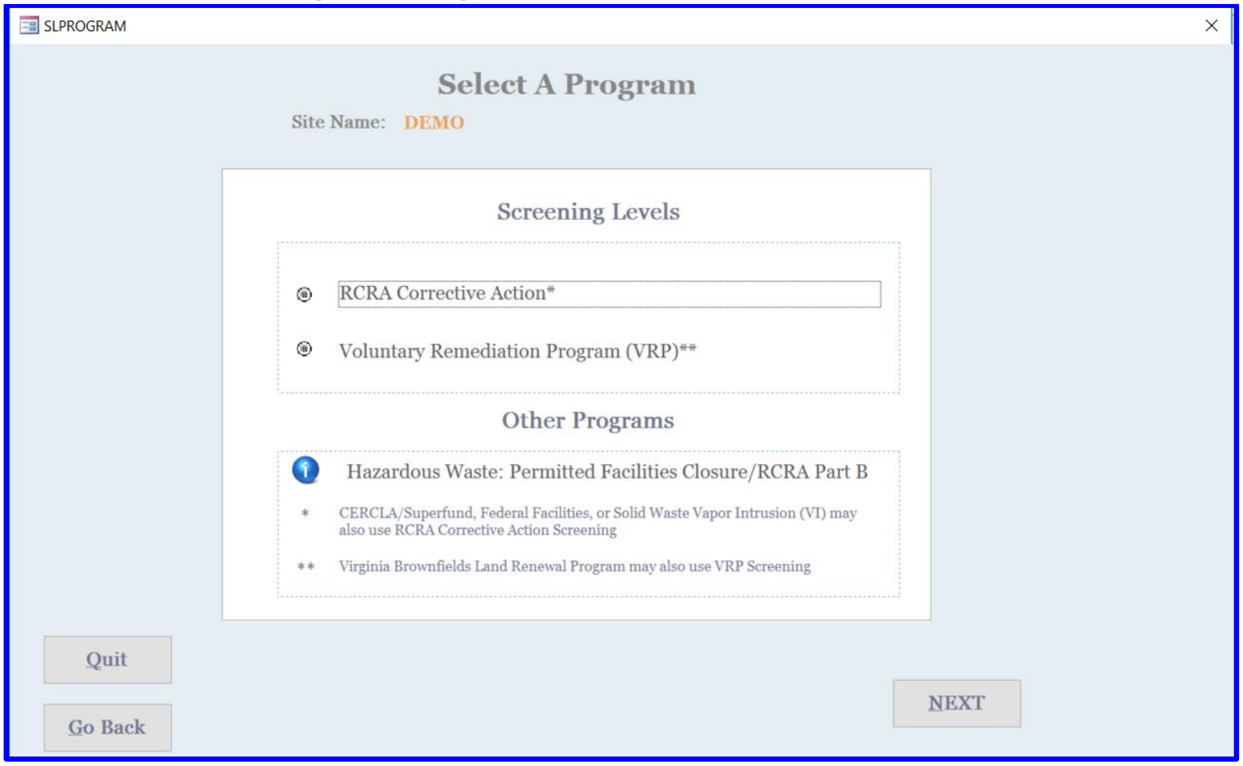
Screening Type	Screening Criteria	Notes
Public Water Supply Tier II	If available Lower of VAWQS* (Freshwater-Chronic, PWS) Otherwise Lower of (Fed HH-Water + Organism, Fed Aquatic-CCC-Fresh)	From National Recommended Water Quality Criteria: Human Health, Aquatic Life, and VAWQS Tables*
Surface Water Fresh Tier II	If available Lower of VAWQS (Freshwater-Chronic, OSW) Otherwise Lower of (Fed HH-Organism Only, Fed Aquatic-CCC-Fresh)*	From National Recommended Water Quality Criteria: Human Health, Aquatic Life, and VAWQS Tables*
Surface Water Marine Tier II	If available Lower of VAWQS (Saltwater-Chronic, OSW) Otherwise Lower of (Fed HH-Organism Only, Fed Aquatic-CCC-Marine)*	From National Recommended Water Quality Criteria: Human Health, Aquatic Life, and VAWQS Tables*

Table 2.5.1e-5 VRP Sediment Screening (mg/kg)

Screening Type	Screening Criteria	Notes
Sediment Tier II	Residential Soil (without DAF 20) × 10	Applicable to VRP ONLY

*Human Health (HH): National Recommended Water Quality Criteria Human Health Criteria Tables Criterion Continuous Concentration (CCC): National Recommended Water Quality Criteria Aquatic Life Criteria Tables Virginia Water Quality Standards (VAWQS): Public Water Supply (PWS), Other Surface Water (OSW), Fresh Water (FW) Chronic, Marine (Mar) Chronic: 9VAC25-260-140

2.5.2 Select a Program Page

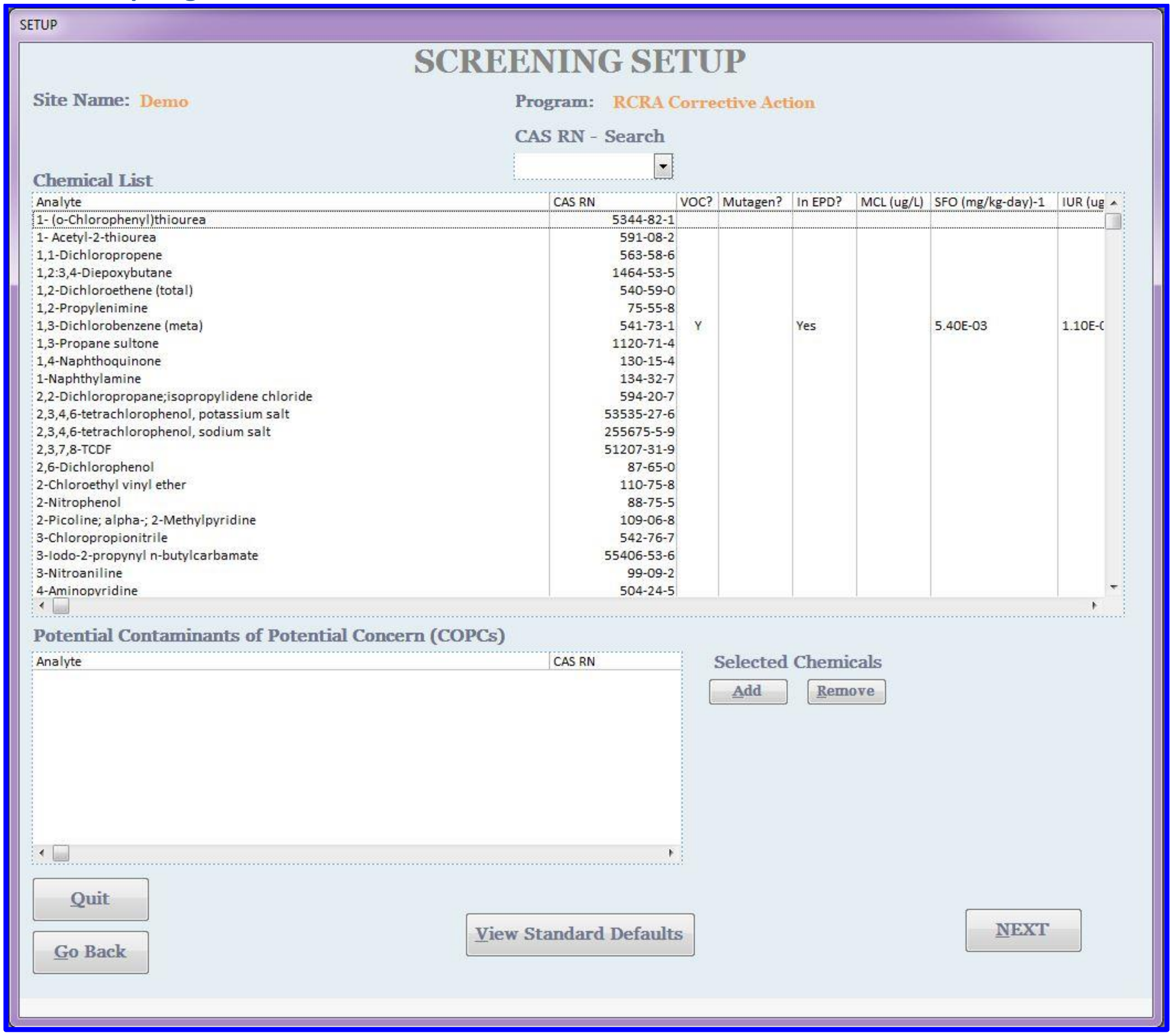


The program page has three options; screening under either RCRA Corrective Action or VRP.

Select the appropriate option to conduct screening and select Next to proceed. To Quit VURAM and return to the Background Page click Quit. To select a different module click Go Back to return to the Introduction Page.

IMPORTANT! For Hazardous Waste Permitted Facilities/RCRA Part B screening evaluation does not apply.

2.5.3 Setup Page



The setup page provides the complete analyte list along with toxicity and chemical parameter values used to compute screening levels.

IMPORTANT! Ensure selection is consistent with the CSM. For more information on developing a CSM see section 1.5.1.

Use the CAS RN Search to look up a chemical by CAS number by typing the CAS RN with dashes, or use the drop-down arrow to scroll through the complete CAS list. Alternately, click on an analyte in the Chemical List to highlight it. Typing the first letter of the chemical name will navigate through the Chemical List. Once the chosen analyte(s) appears highlighted, add it to the Potential Contaminants of Potential Concern (COPCs) List by hitting enter twice, double-clicking the analyte in the Chemical List, or clicking the Add button located next to the Potential COPCs List. The Add button allows also for multiple selections to be added simultaneously. The adjacent Remove button will delete highlighted chemicals from the Potential COPCs List.

Once ALL Potential COPCs have been added to the Potential COPCs List, click Next to proceed with Screening of Environmental Media. To Quit VURAM and return to the Background Page click Quit. To select a different program click Go Back to return to the Select A Program Page.

ALERT! Select **ALL** the chemical analytes for **ALL** sampled media before proceeding. Selected potential COPCs will remain in VURAM memory when returning to this page. However, all medium-specific concentration data entered in Screening will be lost.

2.5.4 Screening Page

The screening page for both RCRA Corrective Action and VRP has a tab group to select from the available environmental media.

For screening purposes, the data for each medium should be sorted by medium. For soil, surface and subsurface soil should be considered separate and two separate VURAM outputs (screening and QRA) should be submitted. For data with qualifiers, check if the qualified data can be retained. Do not eliminate "J" qualifiers. All detected chemicals (maximum concentration) should be entered in the screening module. If quantitation limits for any chemical(s) exceeds screening values, then consult Virginia DEQ PM/Risk Assessor before moving ahead with the QRA/analysis. In order to document the COPC list, as to what is screened in and/or out, it is recommended to enter all chemicals in the screening module.

Select all applicable chemicals from the Chemical List and add them to the COPCs for screening list for each applicable medium. The Add All button will select the entire Chemical List. However, all selected chemicals will require entry of analyte concentration data. The Remove button will remove chemicals from the COPCs list. After selecting all potential COPCs for an environmental medium, click Enter Medium Concentrations to proceed to the Medium Concentrations Page, see section 2.8 and enter sampled or modeled concentrations as appropriate.

IMPORTANT! Analyte concentrations must be entered in the **UNITS OF MEASUREMENT** specified for each medium! Conversion of units may be required before data entry.

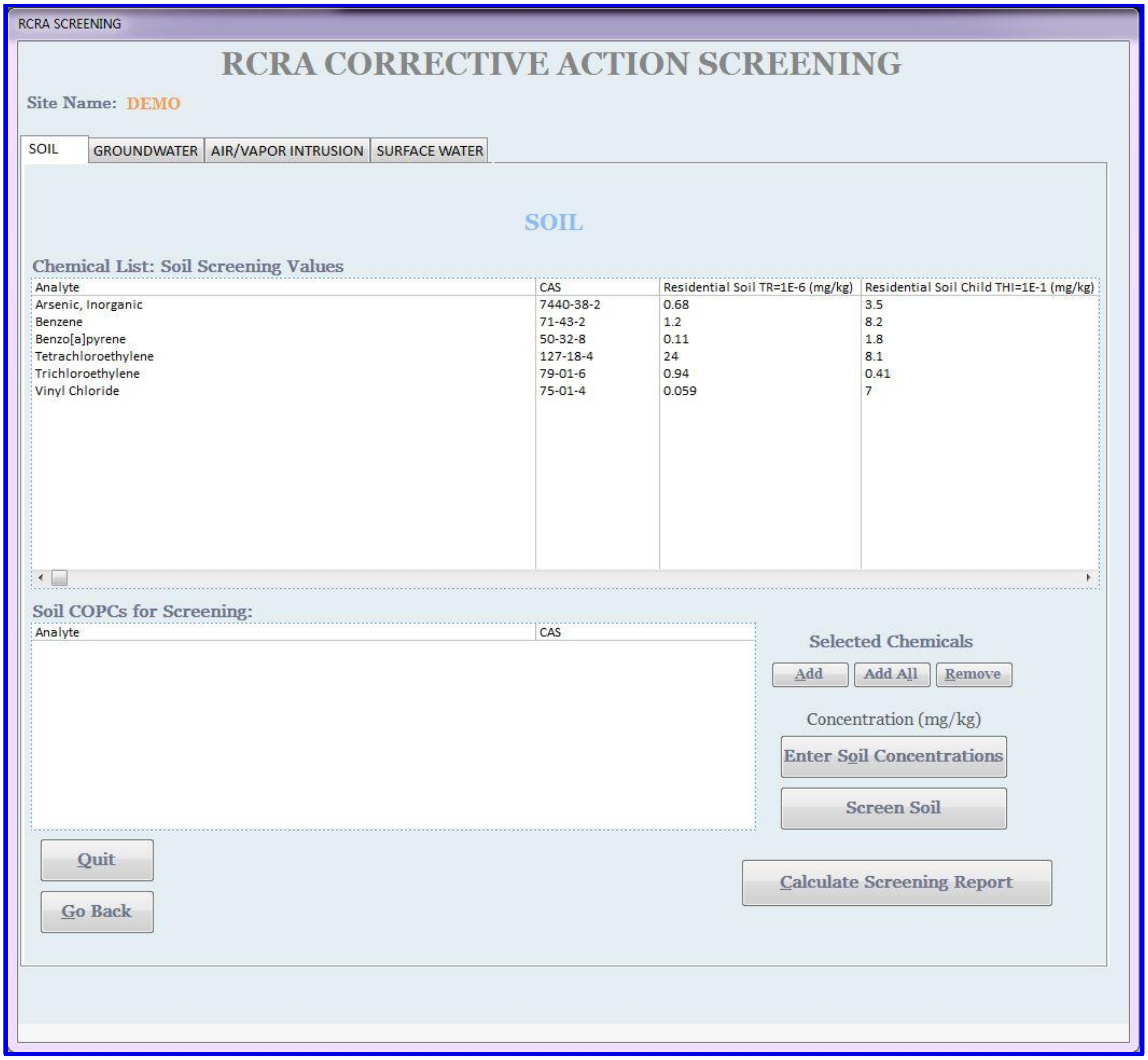
IMPORTANT! Use the maximum concentration for each medium as the exposure concentration for a given pathway to place an upper bound on exposure (RAGS Part A). For non-detects, use ½ of the method detection limit. In cases where the method detection limit exceeds screening values contact the Virginia DEQ project manager and/or risk assessor.

After entering concentrations for an environmental medium, click the Screen Medium button to calculate the COPCs for that medium. Then continue to the next environmental medium, or click Calculate Screening Report button to proceed to the Screening Report. To Quit VURAM and return to the Background Page, click Quit. To return to the chemical selection, click Go Back to return to the Screening Setup Page.

Once the screening calculation is complete for an environmental medium, a green check mark and label will appear across the bottom of the screening page to indicate the screened medium. Any changes to concentrations or analyte selection will cause the medium label and check mark to disappear, indicating that the medium has not been recalculated with the changes. Once concentrations are entered for a given medium, the screening calculation for that medium must be completed to proceed with the report. A red X icon will be displayed next to areas which have not been completed.

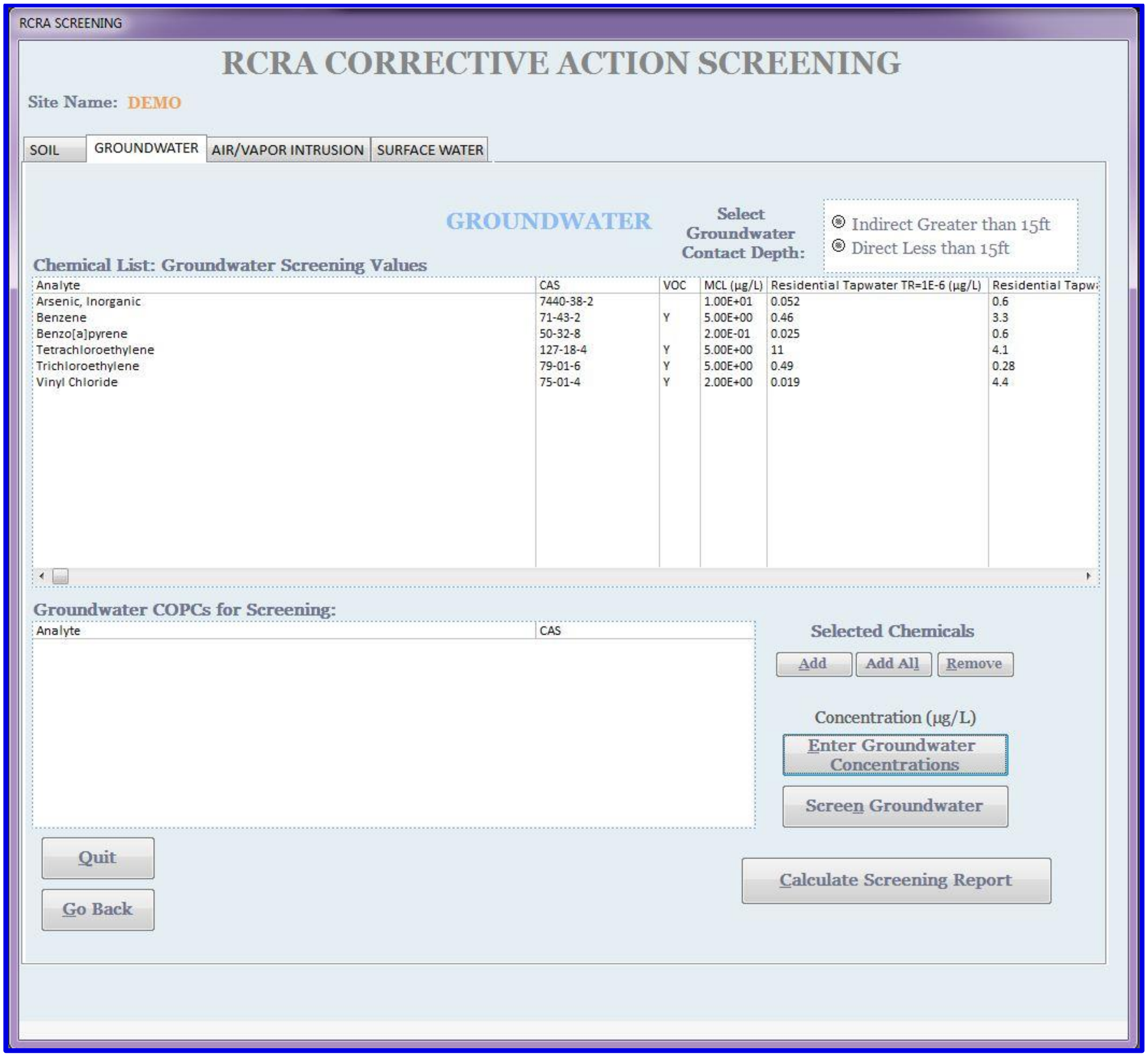
ALERT! The list of potential COPCs will remain in VURAM memory when returning to Screening Setup. However, all environmental medium-specific concentration data entered will be lost.

2.5.4a. Soil Screening Tab



Select soil COPCs for screening then enter soil concentrations. Chemical concentration units for soil are mg/kg. Click the Screen Soil button to compute soil screening results. Proceed to the next environmental medium or click the Calculate Screening Report button.

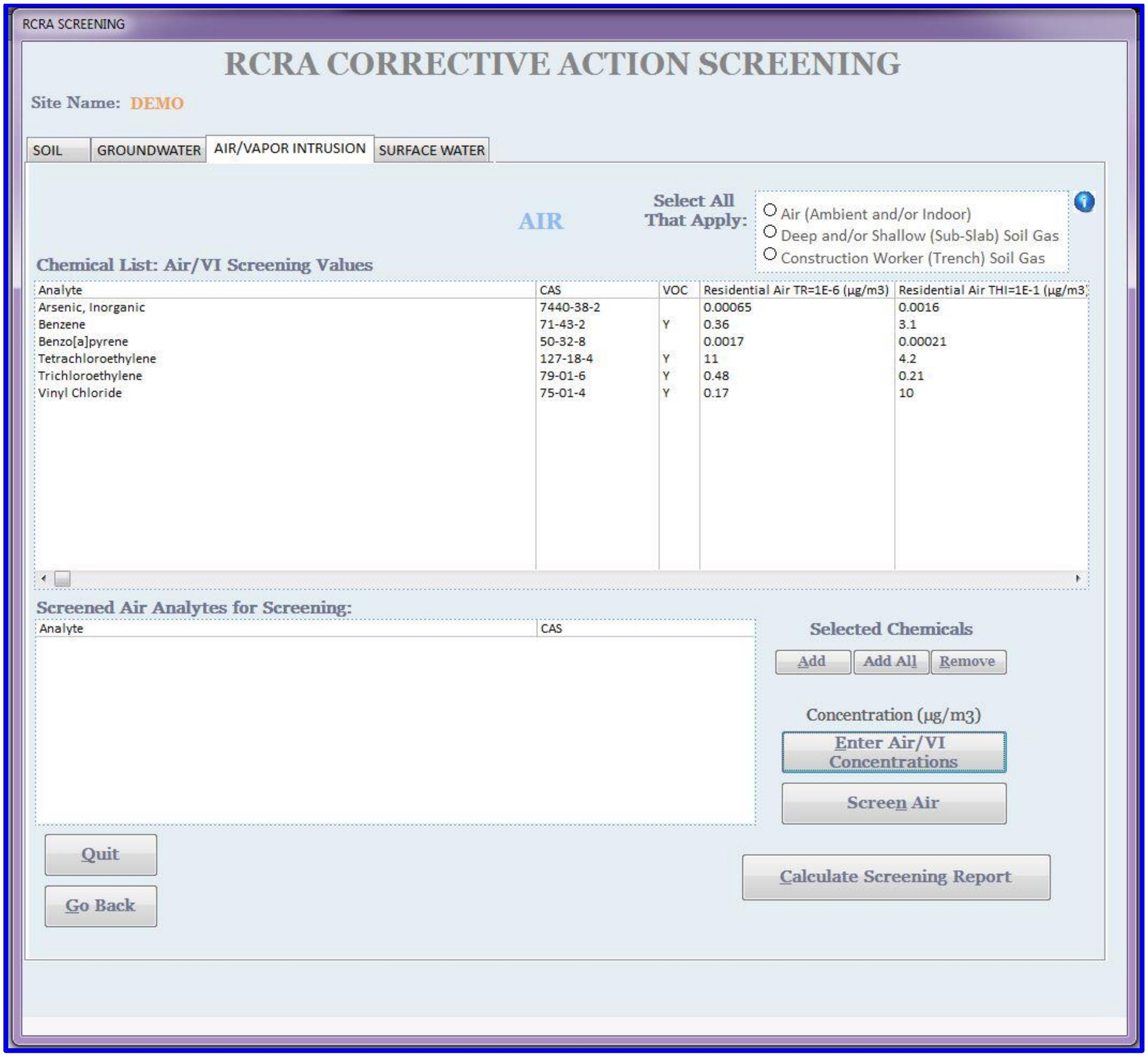
2.5.4b Groundwater Screening Tab



Construction Worker screening values depend on groundwater contact depth. If depth to groundwater is unknown, use the Direct Contact for screening. Select groundwater COPCs for screening; then, enter groundwater concentrations. Chemical concentration units for groundwater are µg/L. Click the Screen Groundwater button to compute groundwater screening results. Proceed to the next environmental medium or click the Calculate Screening Report button.

IMPORTANT! Depth to groundwater selection is required before screening groundwater.

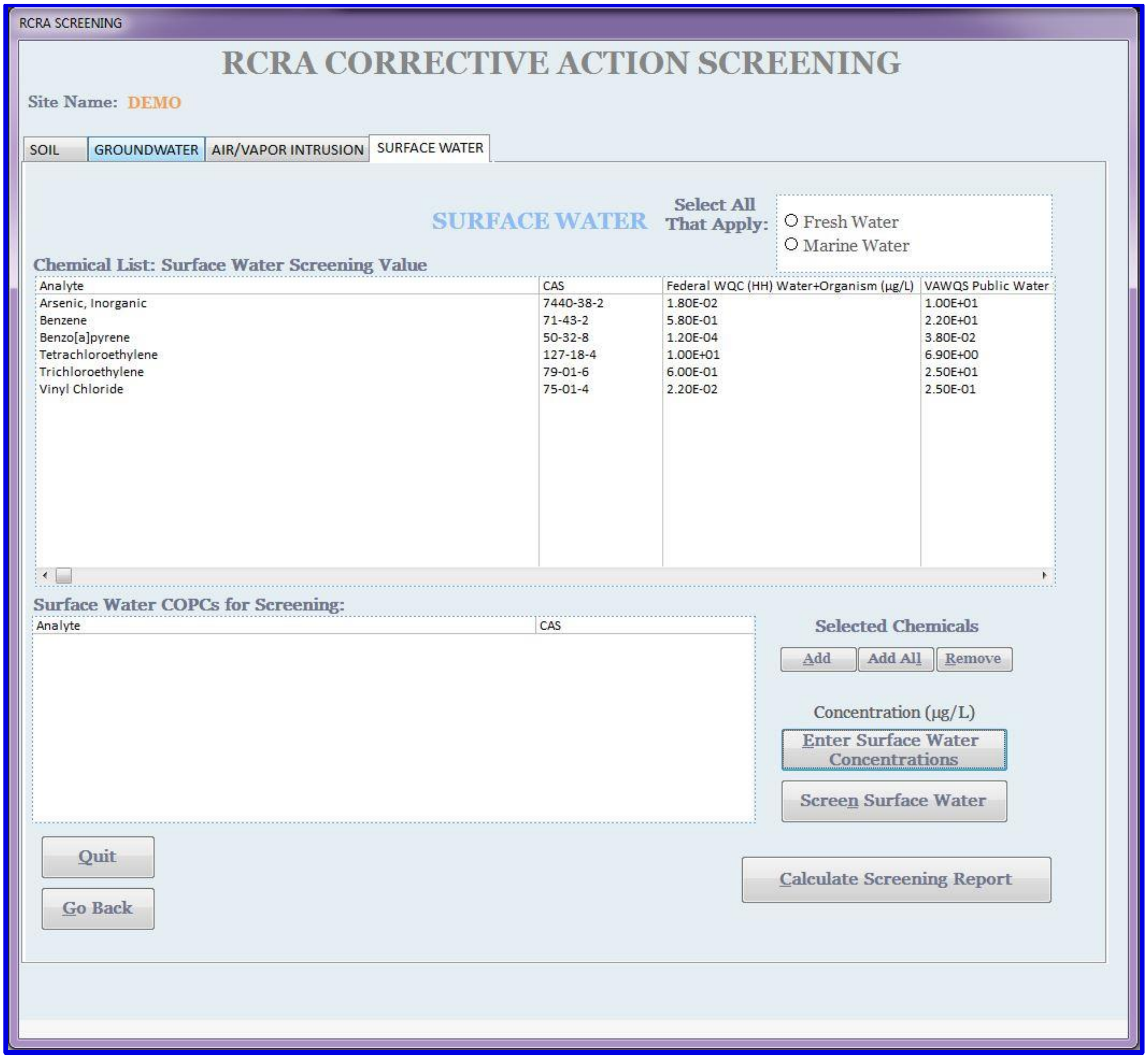
2.5.4c Air/Vapor Intrusion (VI) Screening Tab



The Air/VI evaluation relies on multiple lines of evidence. Select all applicable/sampled lines of evidence (i.e., types of gas or air samples collected). Select air COPCs for screening; then, enter air and soil gas concentrations. Chemical concentration units for air and soil gas are µg/m³. Click the Screen Air button to compute air/VI screening results. Proceed to the next environmental medium, or click the Calculate Screening Report button. Note that direct concentrations (like sub-slab or deep soil gas) should be entered in media concentrations. They do not have to be modeled to indoor air for the screening module.

IMPORTANT! Applicable/sampled lines of evidence must be selected before concentrations are entered.

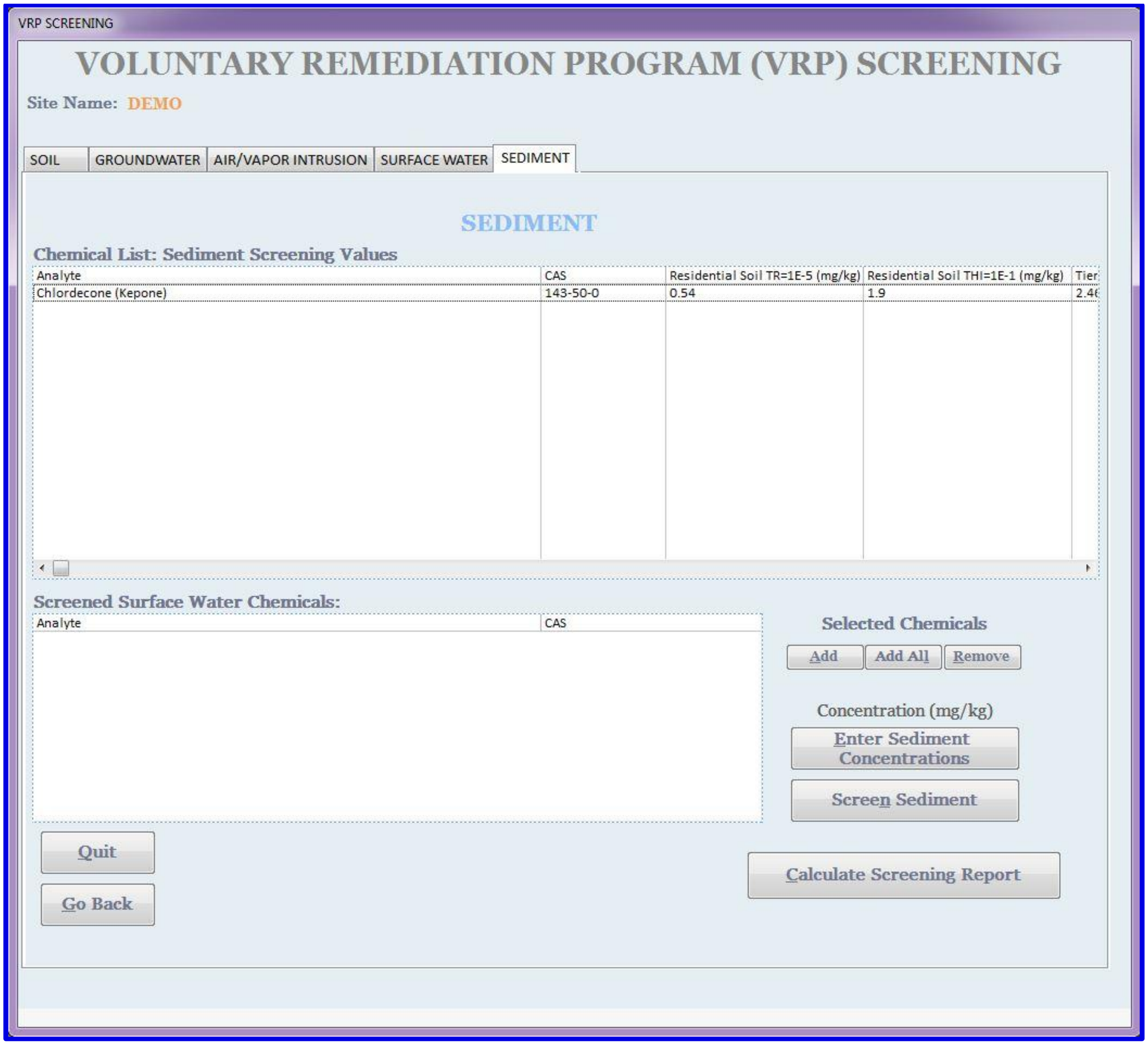
2.5.4d Surface Water Screening Tab



Surface water is screened differently based on fresh or marine criteria. Select Fresh Water and/or Marine Water per the CSM. Select surface water COPCs for screening; then, enter surface water concentrations. Chemical concentration units for surface water are µg/L. Click the Screen Surface Water button to compute surface water screening results. Proceed to the next environmental medium or click the Calculate Screening Report button.

NOTE: If screening methylmercury, CAS 22967-92-6, in surface water, enter fish tissue concentrations in mg/kg instead of µg/L. This fish tissue residue criterion for methylmercury is based on a total fish consumption rate of 0.0175 kg/day.

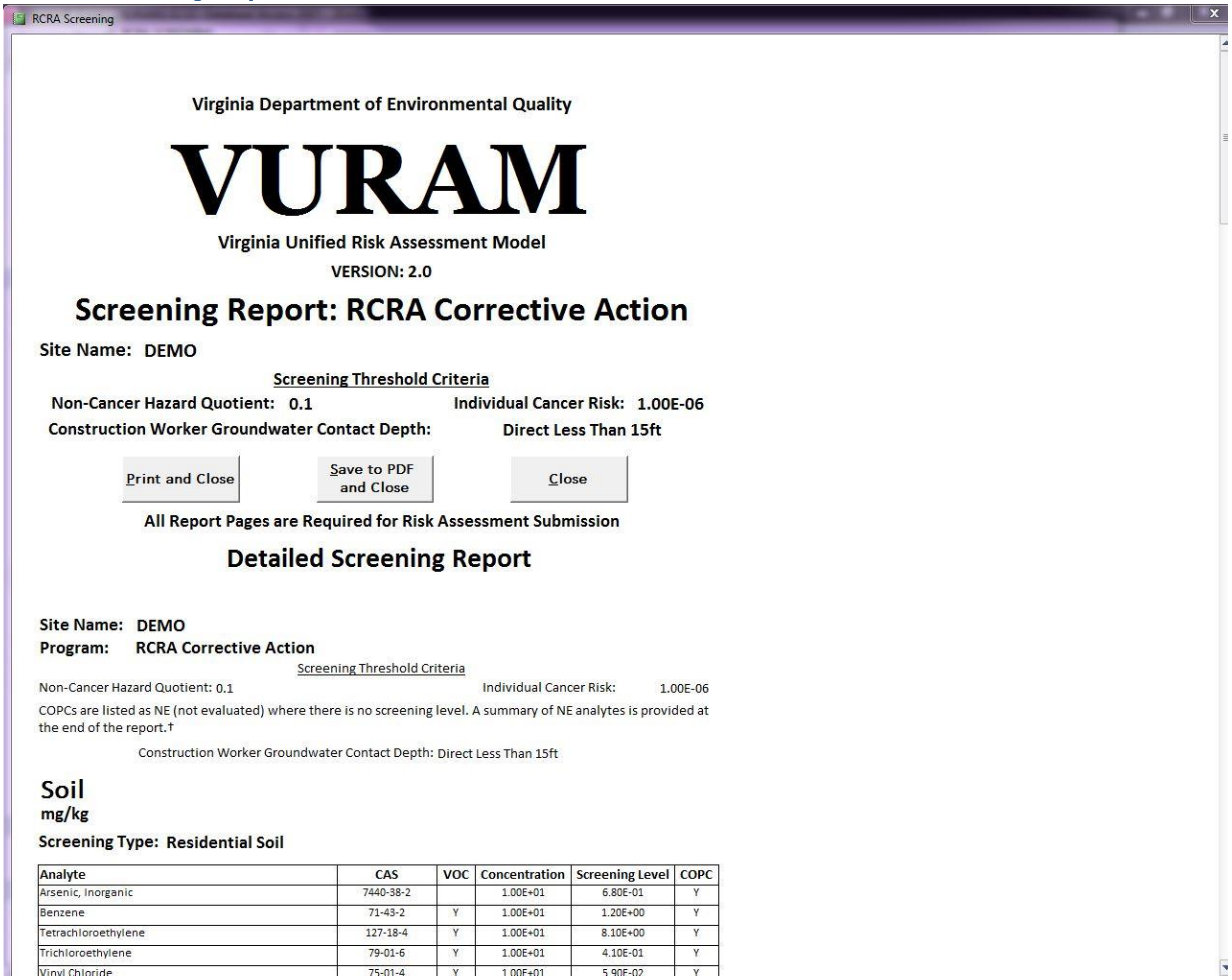
2.5.4e Sediment Screening Tab – VRP ONLY



Select sediment COPCs for screening; then, enter sediment concentrations. Chemical concentration units for sediment are mg/kg. Click the Screen Sediment button to compute sediment screening results. Proceed to the next environmental medium or click the Calculate Screening Report button.

IMPORTANT! Sediment screening is considered Tier II and applicable **ONLY** for the sites in VRP/Brownfields programs and is not for sites covered by other regulatory programs.

2.5.5 Screening Report



Analyte	CAS	VOC	Concentration	Screening Level	COPC
Arsenic, Inorganic	7440-38-2		1.00E+01	6.80E-01	Y
Benzene	71-43-2	Y	1.00E+01	1.20E+00	Y
Tetrachloroethylene	127-18-4	Y	1.00E+01	8.10E+00	Y
Trichloroethylene	79-01-6	Y	1.00E+01	4.10E-01	Y
Vinyl Chloride	75-01-4	Y	1.00E+01	5.90E-02	Y

The screening report opens in MS Access Report View as a single long document; scroll to review the report before proceeding. The Print and Close, Save to PDF and Close, and Close (without saving) buttons located in the header are not visible on the printed/saved version of the report.

IMPORTANT! A report for each screening must be included in the final Human Health Risk Assessment report submitted to DEQ for review and approval.

The Environmental Media Screening Page remains open underneath the report. To make changes to screening concentrations and/or chemical selections, close the report and return to the Environmental Media Screening page.

ALERT! Save or Print the report before exiting the Media Screening page! Screening reports are **NOT** saved in VURAM.

To run a new risk assessment, under the same or different regulatory program, close the report and return to the Screening Setup or Screening Program page as necessary. To proceed to quantitative risk assessment, section 2.7, or background comparisons (VRP Tier I), section 2.9, close the report; then, select Quit from the Screening page to return to the VURAM Background page.

2.5.7a Title Page

Virginia Department of Environmental Quality

VURAM

Virginia Unified Risk Assessment Model

VERSION: 2.0

Screening Report: RCRA Corrective Action

Site Name: DEMO

<u>Screening Threshold Criteria</u>

Non-Cancer Hazard Quotient: 0.1	Individual Cancer Risk: 1.00E-06
Construction Worker Groundwater Contact Depth:	Direct Less Than 15ft

All Report Pages are Required for Risk Assessment Submission

Page 1 of 12

Monday, March 12, 2018

The report title page identifies the VURAM version, selected regulatory program, site name, and screening threshold criteria used in screening. If the report includes groundwater screening, then the selected construction worker groundwater contact depth is also displayed.

IMPORTANT! All pages are required for submission.

2.5.7b Detailed Section

Detailed Screening Report

Trihalomethanes (THMs) and/or Haloacetic Acids (HAAs)*
Methyl Mercury**

Site Name: **DEMO**
Program: **RCRA Corrective Action**

Screening Threshold Criteria

Non-Cancer Hazard Quotient: 0.1 Individual Cancer Risk: 1.00E-06

Surface Water screening values are not applicable to ecological receptors.
Physical and biological parameters are not screened in surface water.
COPCs are listed as NE (not evaluated) where there is no screening level. A summary of NE analytes is provided at the end of the report.†

Soil

mg/kg

Screening Type: Residential Soil

Analyte	CAS	VOC	Concentration	Screening Level	COPC
Arsenic, Inorganic	7440-38-2		1.00E+02	6.80E-01	Y
Benzene	71-43-2	Y	1.00E+02	1.20E+00	Y
Bromoform	75-25-2	Y	1.00E+02	1.90E+01	Y
Methyl Mercury	22967-92-6		1.00E+02	7.80E-01	Y
Trichloroethylene	79-01-6	Y	1.00E+02	4.10E-01	Y
Vinyl Chloride	75-01-4	Y	1.00E+02	5.90E-02	Y

Screening Type: Industrial Soil

Analyte	CAS	VOC	Concentration	Screening Level	COPC
Arsenic, Inorganic	7440-38-2		1.00E+02	3.00E+00	Y
Benzene	71-43-2	Y	1.00E+02	5.10E+00	Y
Bromoform	75-25-2	Y	1.00E+02	8.60E+01	Y
Methyl Mercury	22967-92-6		1.00E+02	1.20E+01	Y
Trichloroethylene	79-01-6	Y	1.00E+02	1.90E+00	Y
Vinyl Chloride	75-01-4	Y	1.00E+02	1.70E+00	Y

Screening Type: Risk-based SSL

Analyte	CAS	VOC	Concentration	Screening Level	COPC
Arsenic, Inorganic	7440-38-2		1.00E+02	1.51E-03	Y
Benzene	71-43-2	Y	1.00E+02	2.33E-04	Y
Bromoform	75-25-2	Y	1.00E+02	8.73E-04	Y
Methyl Mercury	22967-92-6		1.00E+02	1.40E+00	Y
Trichloroethylene	79-01-6	Y	1.00E+02	1.01E-04	Y
Vinyl Chloride	75-01-4	Y	1.00E+02	6.47E-06	Y

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The detailed report section header shows site-specific information from the title page, screening criteria, and relevant chemical-specific notes. VURAM compares the entered chemical concentrations in each screening type to screening levels, if they are available. See section 2.5.1 for screening criteria details.

A table for each screening type provides the screened analyte name, CAS RN, VOC status, entered concentration, screening level, and COPC status. The COPC column displays a “Y”, for “yes”, if the entered concentration exceeds the screening values. If the concentration does not exceed the screening value, then the COPC column is blank. If there is no screening level available, the COPC column shows “NE”, for “not evaluated”. A chemical may not have an established screening value if parameters required to calculate a value are not available, or if the analyte is not relevant to an exposure scenario. Some analytes may have screening levels for some, but not all screened media.

Some header notes are specific to the regulatory program or to particular analytes or environmental media and therefore will not display on every report. Screening Type results may cross pages. If so, the screening type header repeats on next page.

NOTE: For surface water screening methylmercury, CAS 22967-92-6, concentrations are mg/kg instead of µg/L.

NOTE: If screening trihalomethanes (THMs) in groundwater, MCL is not applied. In RCRA, no MCL value for THM is reported. For VRP, risk-based screening values are applied.

IMPORTANT! Surface water and sediment screening values are human health-based and are **NOT** applicable to ecological endpoints. Screening values for sediment are applicable only under VRP.

2.5.7c Summary Section

Detailed Screening Report

Trihalomethanes (THMs) screened in groundwater*
Methylmercury screened in surface water**

Site Name: **DEMO**
Program: **RCRA Corrective Action**

Screening Threshold Criteria

Non-Cancer Hazard Quotient: 0.1 Individual Cancer Risk: 1.00E-06

COPCs are listed as NE (not evaluated) where there is no screening level. A summary of NE analytes is provided at the end of the report.†

Construction Worker Groundwater Contact Depth: Direct Less Than 15ft

Summary of COPCs

Summerized by Residential and Industrial receptor screening for all screened media. Construction Worker screening results are included under the Industrial summary.

Residential

Analyte	CAS
Arsenic, Inorganic	7440-38-2
Benzene	71-43-2
Bromoform	75-25-2
Chlordecone (Kepone)	143-50-0
Chloroform	67-66-3
Methyl Mercury	22967-92-6
Tetrachloroethylene	127-18-4
Trichloroethylene	79-01-6
Vinyl Chloride	75-01-4

Industrial

Analyte	CAS
Arsenic, Inorganic	7440-38-2
Benzene	71-43-2
Chlordecone (Kepone)	143-50-0
Chloroform	67-66-3
Trichloroethylene	79-01-6
Vinyl Chloride	75-01-4

Not Evaluated - NE

Analyte	CAS
Arsenic, Inorganic	7440-38-2
Bromoform	75-25-2
Chlordecone (Kepone)	143-50-0
Chloroform	67-66-3

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The report summary groups COPCs by receptor. RCRA is summarized by Residential and Industrial receptors. VRP is summarized by Tier II Unrestricted and Tier III Restricted. Analytes identified as a COPCs show only once in the summary. However, each analyte may exceed screening in one or more media AND one or more screening type.

NOTE: Construction worker screening results are included in industrial under RCRA and Tier III under VRP.

NOTE: Risk-based SSL, MCL-based SSL, MCL, and surface water screening results are summarized as residential for RCRA and included in Tier II screening criteria for VRP.

NOTE: Groundwater VI, indoor air, ambient air, shallow/sub-slab soil gas, and deep soil gas are summarized as Tier III for VRP.

The report summary includes a list of NE analytes. It is possible for a chemical to be both NE and a COPC if screening values are available in some evaluated screening types but not others. If no screened analytes meet NE criteria (i.e., all screened COPCs in all media have screening values), then a note appears, stating, "No NE Analytes in Screening Level Risk Assessment." Footnotes for chemical and receptor-specific screening appear as applicable. The END OF REPORT note is displayed on the final page after the COPC summary and foot notes.

NOTE: If no analytes are identified as COPCs in the screening evaluation then a one row blank summary table will be displayed. If analytes are identified as COPCs in Residential/Tier II only, then the Industrial/Tier III table will not be displayed.

IMPORTANT! Evaluation of each not evealuated (NE) analyte is required before eliminating it from the COPC list.

IMPORTANT! **ALL** report pages are required for risk assessment submission.

2.7 Quantitative Risk Assessment Module

In the quantitative risk assessment module, VURAM calculates the noncancer Hazard Quotient (HQ) and cancer risk for all entered COPCs for the selected study area, provided that all chemical parameters and toxicity information required for computation are available. Some COPCs may be missing necessary data for computation. See appendix A1.0 and appendix A2.0 for calculation equations and exposure parameters.

IMPORTANT! Ensure selection is consistent with the CSM. For more information on developing a CSM see section 1.5.1.

IMPORTANT! If eliminating COPCs from quantitative risk assessment based on background levels, include the Site-Specific Background Comparison Report. See section 2.9 for details.

IMPORTANT! Uncalculated hazard/risk does not automatically exclude COPCs from the risk assessment.

IMPORTANT! For each medium, use either the maximum detected concentration or the 95% upper confidence limit of the mean, as applicable.

Collect and organize site-specific COPCs and sample data before beginning. Each medium-specific COPC list may contain all or some of the site-specific COPCs. The example table below provides a possible organization of medium-specific COPCs and exposure point concentrations (EPCs). Variation in chemical names may occur, but the CAS number are the most reliable method to identify each analyte.

Table 2.7-1 Example COPC Organization

COPC	CAS	Soil EPC (mg/kg)	Groundwater EPC (µg/L)	Air EPC (µg/m3)
Aluminum	7429-90-5		220500	
Antimony (metallic)	7440-36-0	34.9	24.4	
Arsenic, Inorganic	7440-38-2	91.4	939	
Benzene	71-43-2	2.44		11.11
Benzo[a]pyrene	50-32-8	1.97		18.21
Mercury (elemental)	7439-97-6	2.8		9.98

2.7.1 Calculation Criteria

The general approach to risk assessment is consistent across programs. However, some programmatic differences exist. Once a regulatory program is established, quantitative risk assessment may require re-evaluation under the appropriate program. RCRA Corrective Action calculations follow the CERCLA/Superfund and Federal Facilities risk assessment paradigm. Virginia Brownfields Land Renewal Program may use VRP.

IMPORTANT! For sites where COPCs have migrated offsite, contact Virginia DEQ for offsite data requirements before using the quantitative risk assessment module.

The study area selection consists of residential, industrial/commercial, construction, recreator, and trespasser scenarios. All study areas evaluate hazard/risk for the adult receptor. The residential, recreator, and trespasser scenarios also evaluate the child receptor. A separate risk assessment report is required for each study area evaluated in VURAM. Some or all of the environmental media calculations are available based on the study area and program selections. Unavailable media pages display in gray, with all options inactive. If the CSM requires calculation for an unavailable environmental medium, contact a DEQ project manager or risk assessor for options.

IMPORTANT! Residential use sites include residential use, schools, day care centers, hospitals, nursing homes, parks, and agricultural areas.

IMPORTANT! Include surface water and sediment for sites with surface water on site or adjacent to the site. Surface water and sediment values are human health-based and are **NOT** applicable to ecological endpoints.

2.7.1a Performance Criteria

VURAM requires an acceptable level of cancer risk to be determined based on site-specific factors. Except for RCRA permitted units and facilities, the range for the cumulative acceptable cancer risk performance standard is 1E-4 to 1E-6. The recommended individual risk is at or below 1E-6, except under the VRP, which by regulation accepts an individual risk at or below 1E-5. For RCRA permitted units and facilities, the acceptable combined risk performance standard from all carcinogenic risk from all exposure pathways and media for a given receptor is 1E-04. For individual carcinogenic risk performance standard from all exposure pathways and media for a given receptor is 1E-6. Options to select individual and cumulative risk-based performace standards are provided in VURAM and may be selected as appropriate.

A hazard index is the sum of HQs for COPCs with noncarcinogenic effects. For example, exposure to contaminated soil involves potential ingestion, inhalation of particulates and volatiles, and dermal contact. Therefore, the hazard index for an individual COPC is the sum of the exposure pathway HQs associated with each of the three routes of exposure. HQs are combined to yield a hazard index for each COPC calculated, all COPCs in a given environmental medium, and a site-wide total hazard index. The performance criteria, both-for individual noncarcinogens and for the sum of all noncarcinogens, is a hazard index no greater than 1.

IMPORTANT! The hazard index is not derived using the target organ-specific HQ. Target organ data are provided on the setup pages in VURAM in order to calculate the sum of HQs for substances that affect the same target organ or organ system.

IMPORTANT! Based on EPA Region 3 recommendation, dermal risk for chemicals outside of the effective predictive domain (EPD) are quantitatively assessed. For more information, refer Region 3 Updated Dermal Exposure Assessment Guidance.

IMPORTANT! In the absence of speciation data, all chromium concentrations are assumed to be in hexavalent form, chromium VI, CAS 18540-29-9.

2.7.1b Groundwater Notes

For all study areas except construction worker, groundwater inhalation does not reflect the vapor intrusion pathway (shallow/sub-slab or deep soil gas). Inhalation from groundwater refers to the inhalation of vapors during all uses of household water (e.g., showering, laundering, dish-washing, etc.) and includes all possible exposures to volatilized air concentrations of contaminants that derive from contaminated tapwater in a residence.

Construction Worker groundwater exposure is based on the Virginia DEQ Construction Worker Trench Model. Select the groundwater depth based on shallowest groundwater on the site. For a groundwater depth of less than 15 feet (direct contact), groundwater is assumed to pool in the trench. Therefore, all exposure pathways—ingestion, inhalation, and dermal—apply. At groundwater depths greater than 15 feet (indirect contact), VOC contaminant transport through the vadose zone is assumed, and only the inhalation pathway applies. For both scenarios, the inhalation pathway is evaluated only for those COPCs marked as VOC in the RLS table.

IMPORTANT! For RCRA Corrective Action, consult both the groundwater screening and soil risk-based SSL (DAF-1) screening results to evaluate the soil-to-groundwater pathway. Additional modeling and/or groundwater monitoring may be required before conducting risk assessment for groundwater exposure.

Virginia DEQ considers drinking water as the highest beneficial use for groundwater. Therefore, groundwater calculations use residential exposure defaults and equations. Groundwater is available for the industrial/commercial study area under RCRA Corrective Action, RCRA Part B, and VRP.

For VRP in QRA, under the industrial/commercial study area, selection of a groundwater declaration is required. Select beneficial use to compute groundwater, if groundwater will have a potable use at the site.. Select restricted use if Tier III screening levels are applicable **AND** there is a proposed groundwater restriction at the site. For more details concerning the groundwater declaration under VRP contact DEQ risk assessor or project manager.

IMPORTANT! QRA under the VRP progam cannot be finalized unless the right groundwater use declaration is selected.

IMPORTANT! Restricted use of groundwater is for onsite use **ONLY**. Evaluate potential offsite risks and receptors separately. For the restricted use declaration to apply the nature and extent of the groundwater plume must be sufficiently characterized and concentrations along the vertical and horizontal migration of the plume must be stable.

2.7.1c Air and Vapor Intrusion (VI) Notes

Use measured or calculated air concentrations for evaluating inhalation hazard/risk from indoor (via vapor intrusion) or outdoor (ambient) air exposure. The concentration input for this exposure scenario includes **ONLY ONE** of the following: measured concentration from sub-slab gas, shallow soil gas, deep soil gas, indoor air, or outdoor air, **OR** calculated air concentration from groundwater-to-indoor air calculations, output from air dispersion model, or any other Virginia DEQ-approved model results that generate fate-and-transport model-based air concentration.

IMPORTANT! For VI evaluation where multiple lines of evidence are available, enter the concentration that shows maximum exceedance of screening levels.

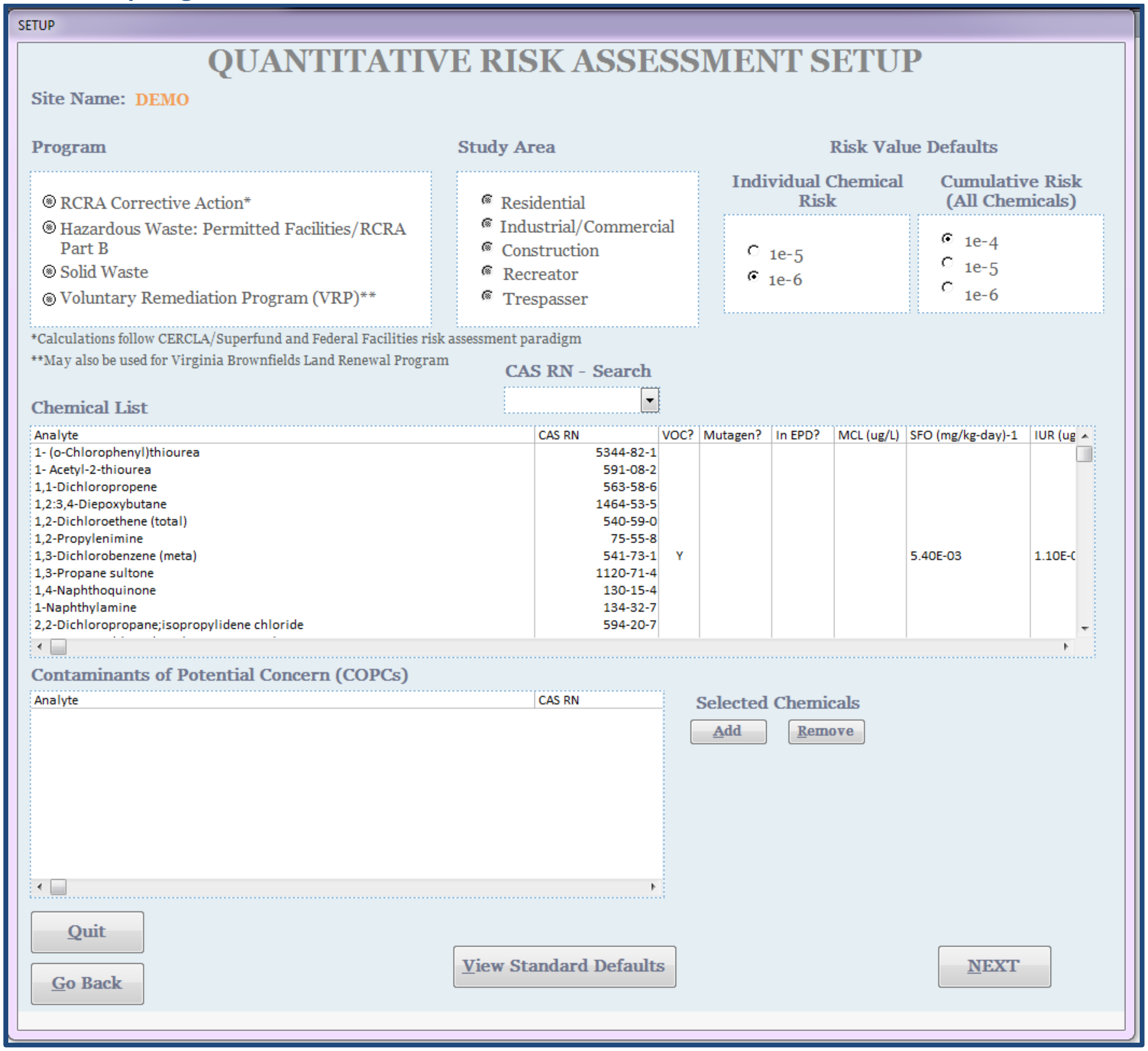
IMPORTANT! EPA no longer recommends the Johnson and Ettinger (J&E) model for indoor air calculations and instead recommends the Vapor Intrusion Screening Level (VISL) calculator. Virginia DEQ recommends the VISL Calculator.

2.7.1d Construction Notes

The construction study area calculates the air inhalation pathway using the Virginia DEQ Construction Worker Trench Model for soil gas. Shallow/sub-slab or deep soil gas may be used as concentration values for evaluating the exposure to a construction worker in a trench. This inhalation value is distinct from the groundwater inhalation pathway.

EPA RSL equations are used to compute construction soil, however, construction worker exposure defaults for soil under VRP differ slightly from other programs. The construction worker scenario for all environmental media and under all programs uses sub-chronic toxicity values where available, and chronic toxicity values otherwise. The Virginia DEQ Construction Worker Trench Model applies to calculations of groundwater and air for the construction study area. See appendix A1.3 for construction soil and appendix A2.0 for the Virginia DEQ Construction Worker Trench Model.

2.7.2 Setup Page



The setup page provides options for the program, study area, and risk value defaults along with the complete analyte list showing toxicity and chemical parameter values used to compute noncancer hazard and cancer risk levels. Select the appropriate regulatory program under which to compute the risk assessment and study area under which to conduct calculations.

The setup page opens with risk value defaults set according to RCRA Corrective Action guidance. For VRP risk assessment, individual chemical risk can be changed to 1E-5. Any other changes to risk defaults require advance consultation with Virginia DEQ. Contact the project manager or risk assessor to confer on risk value defaults.

Use the CAS RN Search to look up a chemical by CAS number by typing the CAS RN with dashes, or use the drop-down arrow to scroll through the complete CAS list. Alternately, click on an analyte in the Chemical List to highlight it. Typing the first letter of the chemical name will navigate through the Chemical List. Once the chosen analyte(s) appears highlighted add them to the COPCs List by hitting enter twice, double-clicking the analyte in the Chemical List, or clicking the Add button located next to the COPCs List. The Add button also adds multiple selections simultaneously. The adjacent Remove button will delete highlighted chemicals from the COPCs List.

ALERT! Select ALL the chemical analytes for ALL sampled media before proceeding. Selected COPCs will remain in VURAM memory when returning to this page. Changes can be made to the program, study area, risk value defaults, and COPCs List after calculations are run. However, all medium-specific concentration data entered in calculations will be lost.

Once ALL COPCs have been added to the COPCs List, click Next to proceed to Calculations. To end the VURAM session and return to the Background Page, click Quit. Click Go Back to return to the Introduction Page. To review the values used in all risk computations, click the View Standard Defaults button, see section 2.3 for details.

2.7.3 Calculation Pages

The quantitative risk assessment calculation page has a tab group to select from the available environmental media. Each tab contains medium-specific selection options for calculation and a Chemical List that includes the analyte name and CAS. This Chemical List is reflective of the selection of COPCs from the previous page. Select all applicable computation options and add all applicable chemicals from the Chemical List to the COPCs List for each applicable medium. The Add All button will select the entire Chemical List. However, all selected chemicals must have analyte concentration data. The Remove button will remove chemicals from the COPCs List. After selecting ALL COPCs for an environmental medium click Enter Medium Concentrations to proceed to the Medium Concentrations Page and enter sampled or modeled concentrations as appropriate.

IMPORTANT! Analyte concentrations must be entered in the **UNITS OF MEASUREMENT** specified for each medium. Conversion of units may be required before data entry.

After entering concentrations for an environmental medium, click the Calculate Medium button to calculate the hazard/risk values for that medium. Continue to next environmental medium or click Calculate Total Risk/Hazard Report button if ready to proceed to the Study Area Quantitative Risk Assessment Report. To quit VURAM and return to the Background page, click Quit. To return to the chemical selection or change the program or study area, click Go Back to return to the Setup Page.

Once calculations are complete for an environmental medium, a green check mark and label will appear across the bottom of the page to indicate the completed medium. Any changes to concentrations or analyte selection will cause the medium label and check mark to disappear, indicating that the medium has not been recalculated with the changes. Once concentrations are entered for a given medium, the calculations for that medium must be completed to proceed with the report. A red X icon will be displayed next to areas which have not been completed.

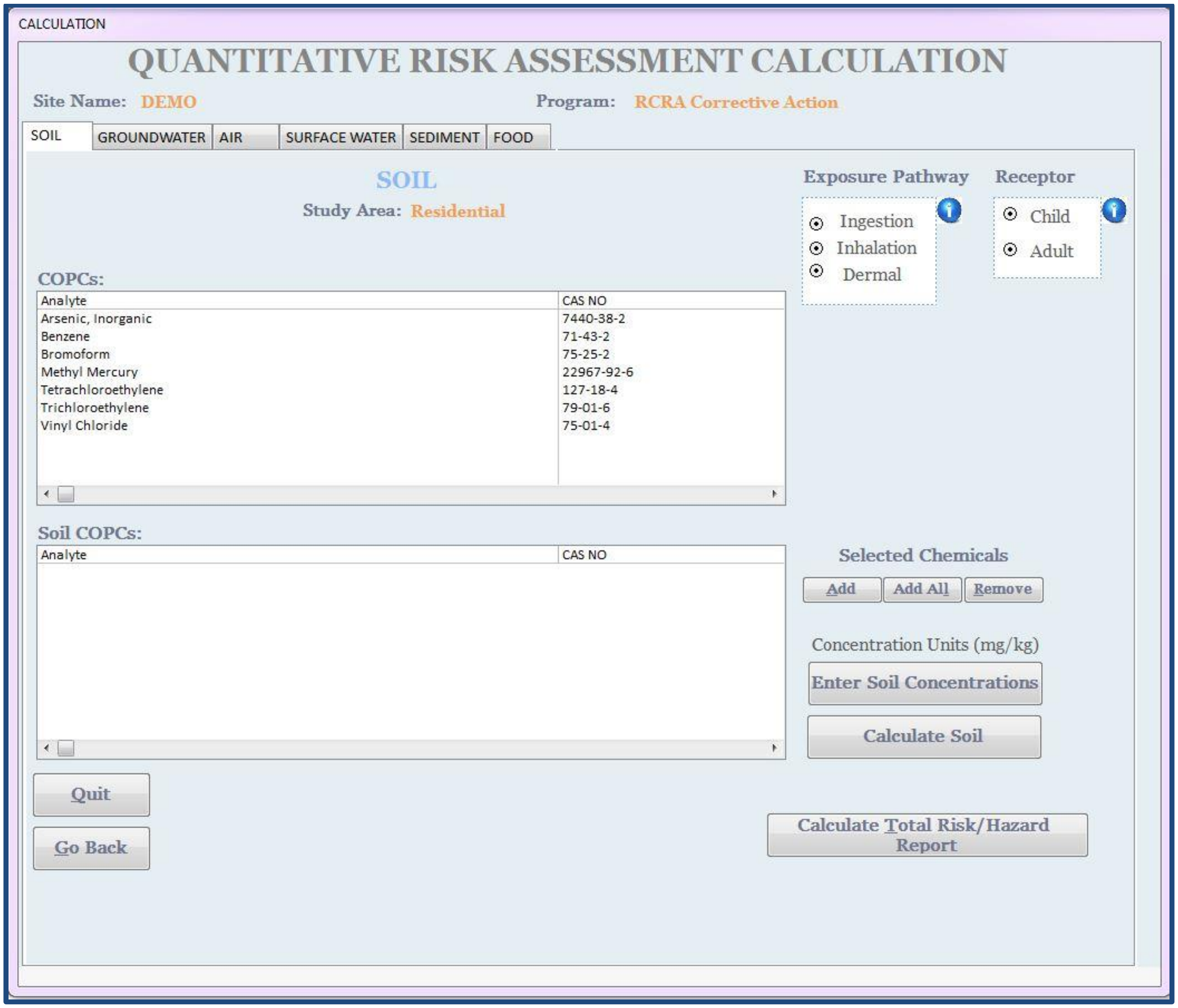
ALERT! COPCs will remain in VURAM memory when returning to the Setup Page. However, all environmental medium-specific concentration data entered will be lost.

Table 2.7.3-1 Calculation Notes by Environmental Media Summary

Environmental Media	Ingestion	Inhalation	Dermal	Notes
Soil	Yes	Yes	Yes	Not available under Solid Waste Program

Environmental Media	Ingestion	Inhalation	Dermal	Notes
Groundwater	Yes	Yes	Yes	Industrial evaluated using residential exposure defaults and equations Groundwater Declaration required for industrial/commercial under VRP Construction calculated using DEQ Trench Model Construction exposure pathways are dependent on depth to groundwater Industrial study area not available under Solid Waste Program Not available for recreator or trespasser study areas
Air	No	Yes	No	Use the concentration that shows the maximum exceedance of screening levels Use **ONLY ONE** measured **OR** calculated concentration Construction calculated using DEQ Trench Model for soil gas Calculations are independent of age; noncancer hazard reported to both child and adult totals Not available under Solid Waste Program Not available for recreator or trespasser study area
Surface Water	Yes	No	Yes	Residential calculations use recreator equations and exposure defaults Not available under Solid Waste Program Not available for industrial/commercial or construction study areas
Sediment	Yes	Optional	Yes	Residential calculations use recreator equations and exposure defaults Select Inhalation based on site-specific COPCs Not available under Solid Waste Program Not available for industrial/commercial or construction study areas
Food	Yes	No	No	Available for residential study area only For nonresidential study areas, re-run VURAM as residential and evaluate food only; submit both reports with risk assessment Select one or more food media (food groups); all selections must have entered concentrations for all selected COPCs Not available under Solid Waste Program Calculations are independent of age

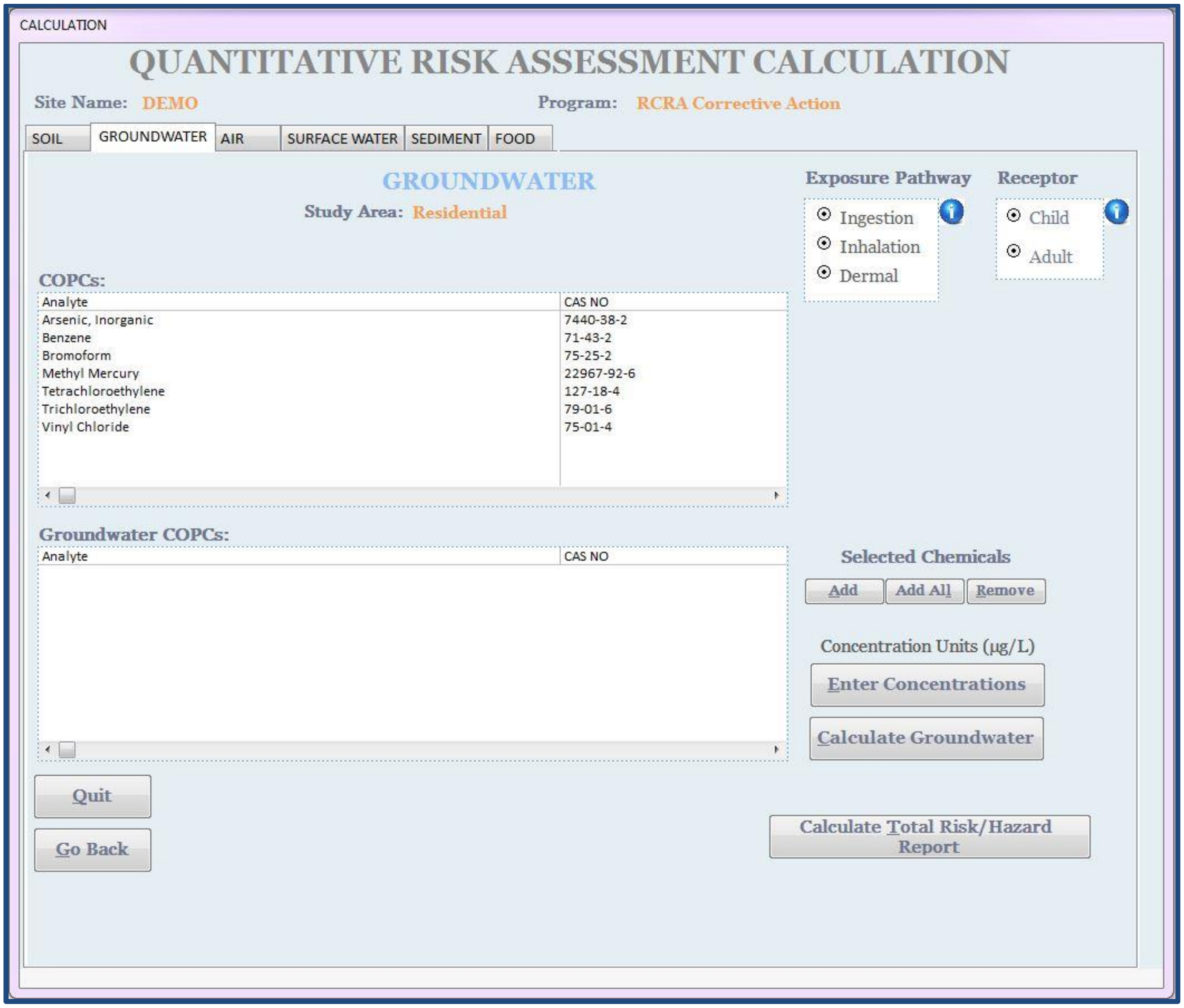
2.7.3a Soil Calculation Tab



The soil calculation page is consistent across all programs and study areas. Soil calculations are not available under the Solid Waste Program for all study areas.

Select soil COPCs; then, enter soil concentrations. Chemical concentration units for soil are mg/kg. Click the Calculate Soil button to compute quantitative soil results. Proceed to the next environmental medium or click the Calculate Total Risk/Hazard Report button.

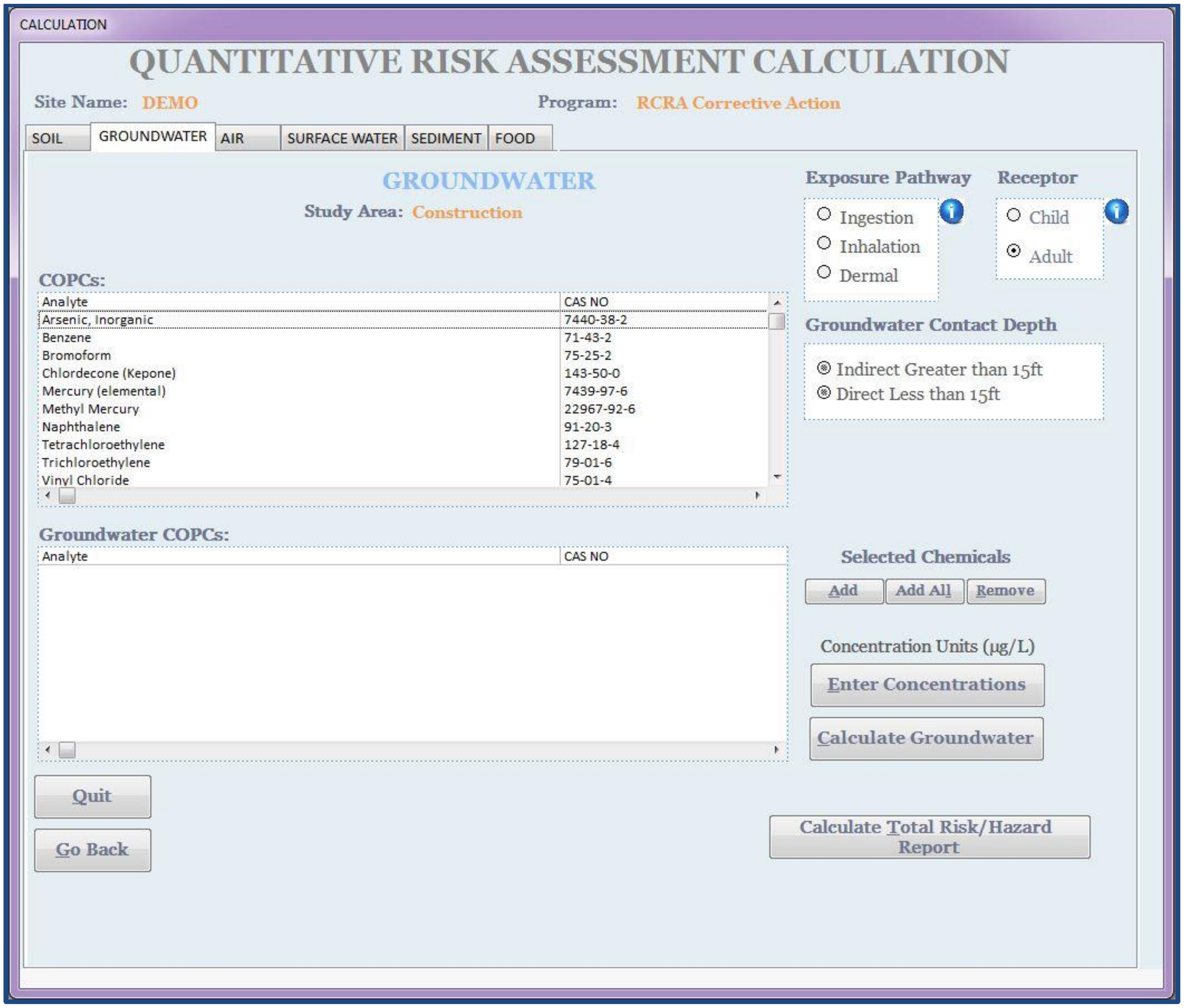
2.7.3b Groundwater Calculation Tab



Select groundwater COPCs; then, enter groundwater concentrations. Chemical concentration units for groundwater are µg/L. Click the Calculate Groundwater button to compute quantitative groundwater results. Proceed to the next environmental medium or click the Calculate Total Risk/Hazard Report button.

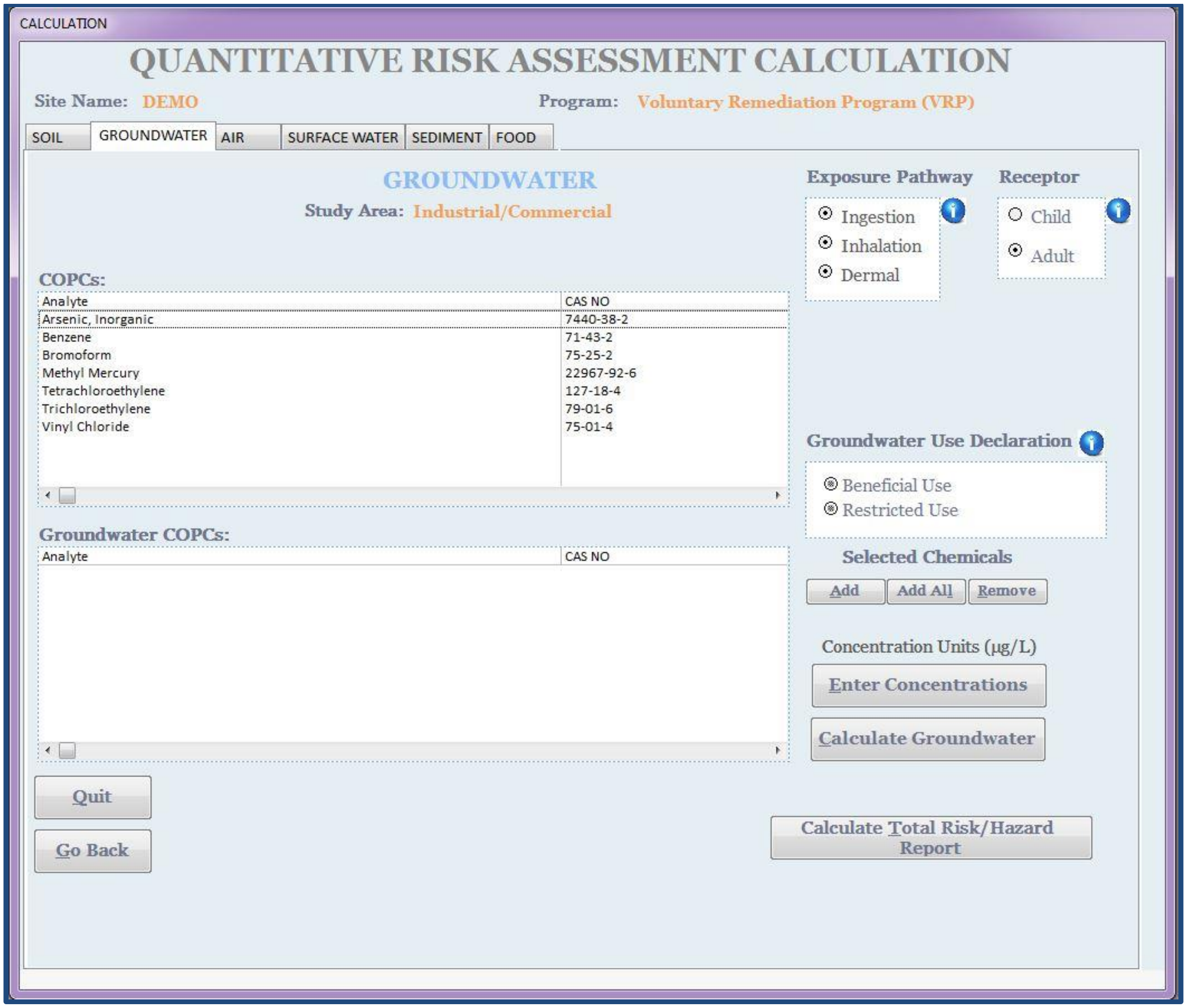
Virginia DEQ considers drinking water to be the highest beneficial use for groundwater. Residential and industrial study areas are evaluated using residential exposure defaults and equations. Groundwater is not available for the industrial study area under the Solid Waste Prorgram. Construction calculations use the DEQ Construction Worker Trench Model equations; see appendix A2.0. For the construction study area, a depth to groundwater selection is required. The industrial study area under VRP requires a groundwater declaration, regardless of groundwater COPCs.

IMPORTANT! Groundwater contaminant concentrations must be evaluated with respect to fate and transport.



For the construction study area, a Groundwater Contact Depth option box will be displayed beneath the Exposure Pathway and Receptor options. Depth to groundwater must be selected to proceed with calculations. The exposure pathway(s) will be automatically selected based on the Groundwater Contact Depth.

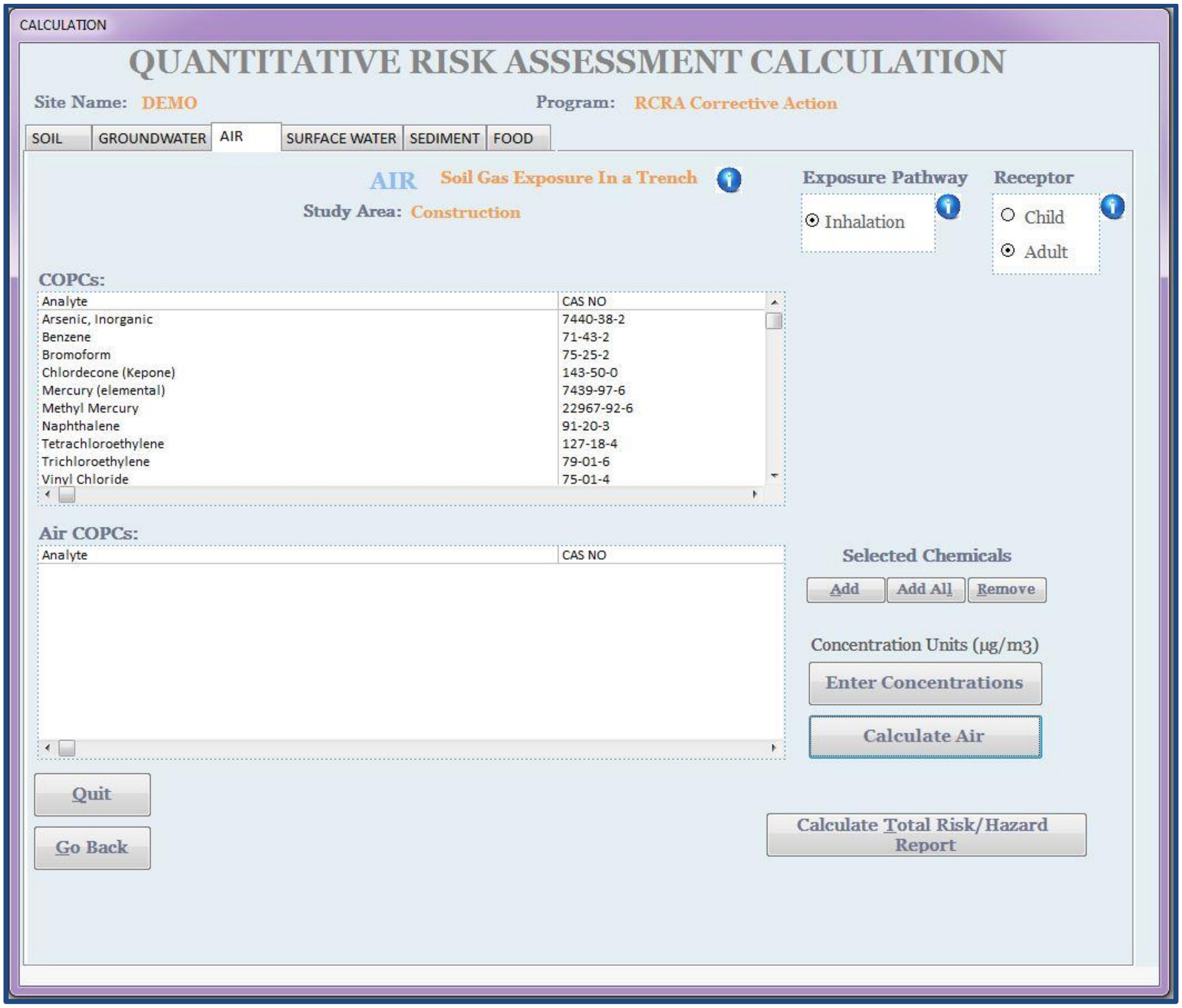
IMPORTANT! Select the shallowest groundwater depth at the site. If depth to groundwater at the site is unknown, select Direct Less than 15 ft.



For the industrial study area (under VRP only), a groundwater use declaration is required. The Groundwater Use Declaration option and info icon will appear below the Exposure Pathway and Receptor options. Select Beneficial use to calculate groundwater or Restricted Use to exclude it, as applicable.

IMPORTANT! Groundwater Use Declaration is required for the industrial study area under VRP, regardless of the evaluation of the groundwater medium.

2.7.3c Air Calculation Tab



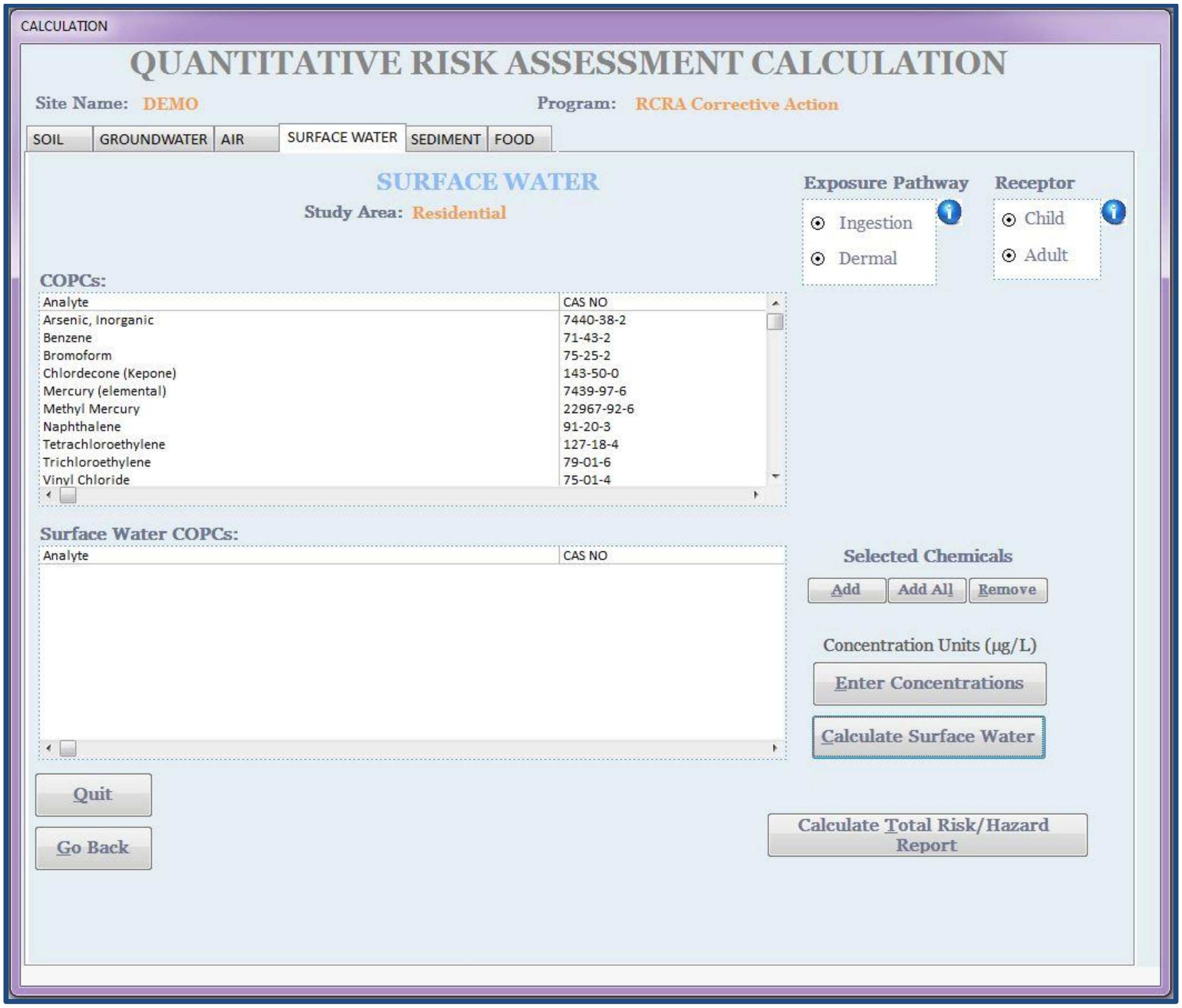
Select air COPCs; then, enter air concentrations. Chemical concentration units for air are µg/m^3. Click the Calculate Air button to compute quantitative air results. Proceed to the next environmental medium or click the Calculate Total Risk/Hazard Report button.

Air VI risk estimates rely on multiple lines of evidence. For quantitative risk assessment air hazard/risk values are computed using indoor air equations for residential and industrial study areas. To convert soil gas to indoor air concentrations, refer to EPA's VISL calculator. The construction study area is calculated using the DEQ Construction Worker Trench Model for soil gas.

IMPORTANT! Use **ONLY ONE** measured **OR** calculated concentration.

IMPORTANT! If multiple measured or calculated concentrations are available for a given COPC, use the concentration which shows the maximum exceedance of screening levels.

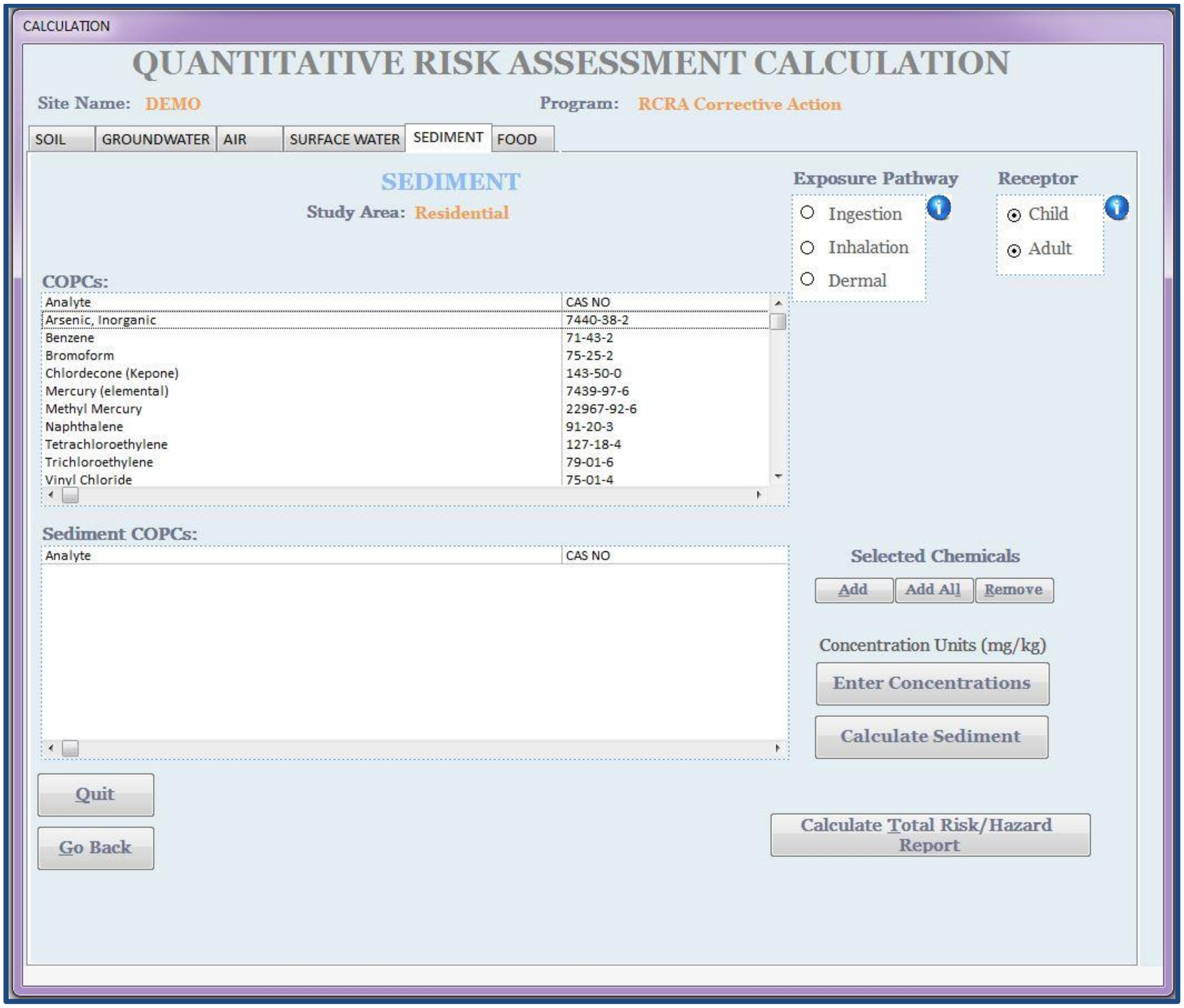
2.7.3d Surface Water Calculation Tab



Select surface water COPCs; then, enter surface water concentrations. Chemical concentration units for surface water are µg/L. Click the Calculate Surface Water button to compute quantitative surface water results. Proceed to the next environmental medium or click the Calculate Total Risk/Hazard Report button.

Surface water is available for residential, recreator, and trespasser study areas only and is not available under the Solid Waste Program. Residential study area calculations use recreator equations and exposure defaults.

2.7.3e Sediment Calculation Tab

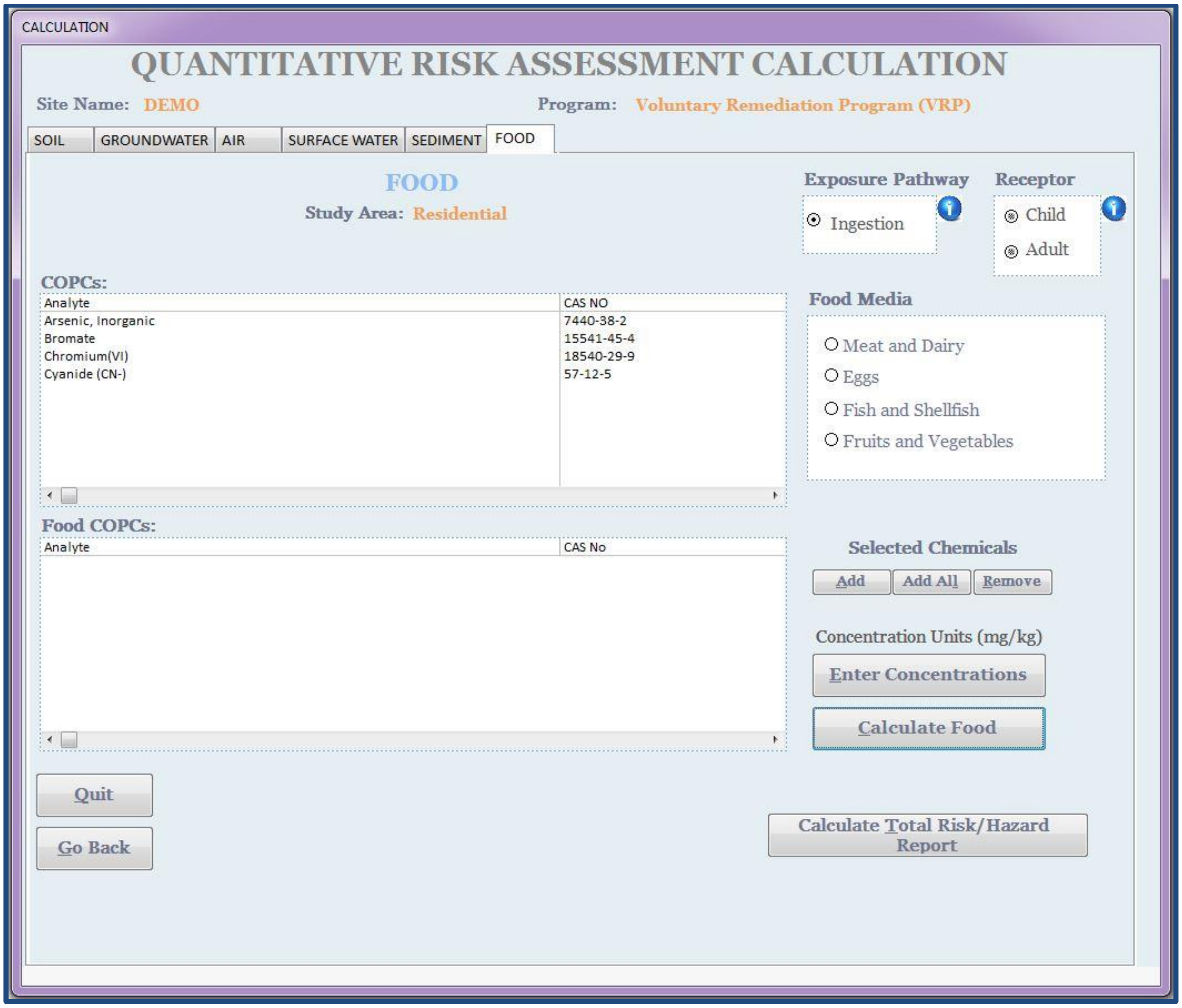


Select sediment COPCs; then, enter sediment concentrations. Chemical concentration units for sediment are mg/kg. Click the Calculate Sediment button to compute quantitative sediment results. Proceed to the next environmental medium or click the Calculate Total Risk/Hazard Report button.

Sediment is available for residential, recreator, and trespasser study areas only and is not available under the Solid Waste Program. Residential study area calculations use recreator equations and exposure defaults.

IMPORTANT! Dermal and ingestion exposure pathways are required. Inhalation exposure pathway can only be evaluated if manually selected for certain COPCs.

2.7.3f Food Calculation Tab

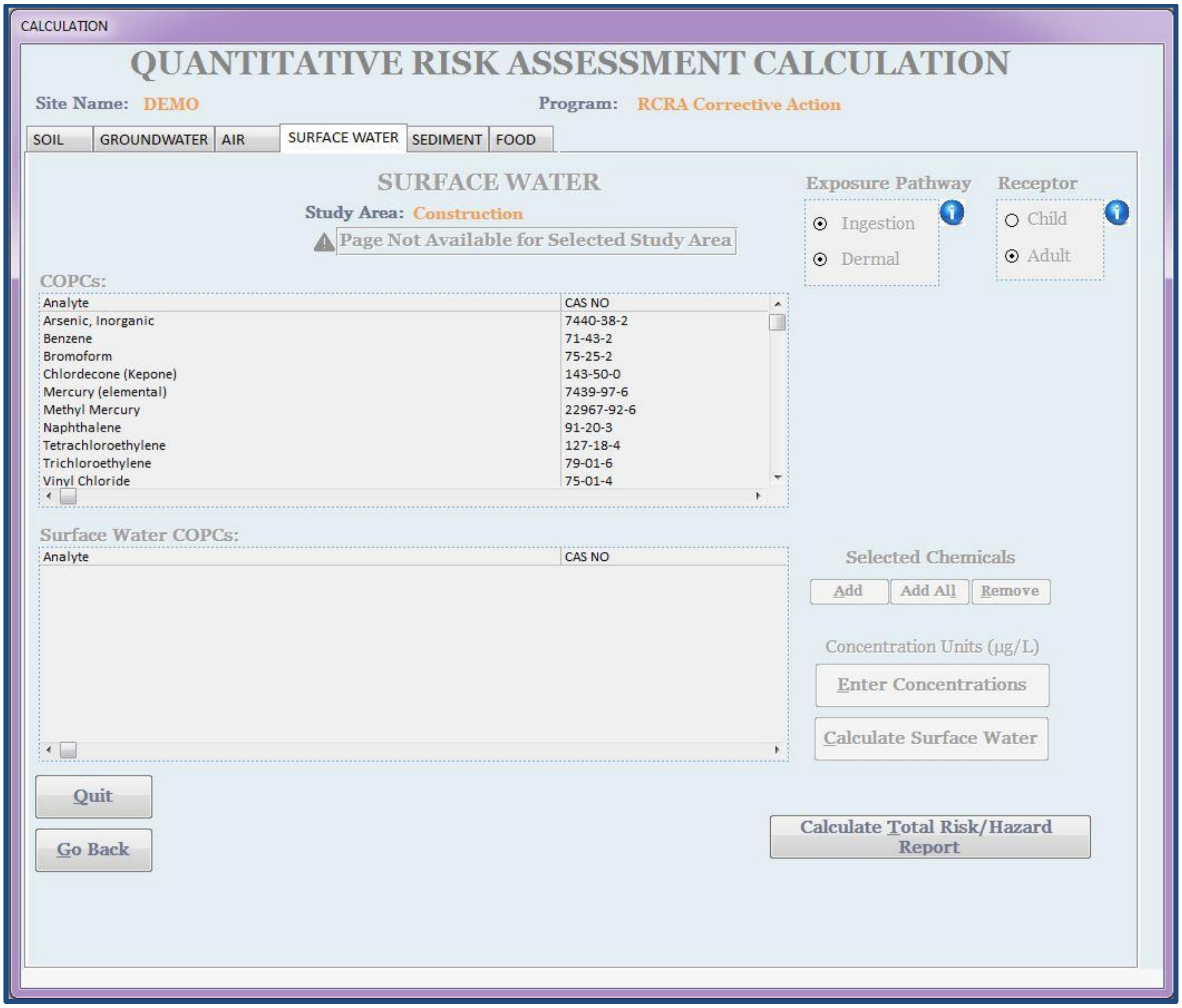


The food medium is divided into food groups of meat and dairy, eggs, fish and shellfish, and fruits and vegetables. Select one or more of the food groups. Select food COPCs; then, enter food concentrations. Chemical concentration units for food are mg/kg. Click the Calculate Food button to compute quantitative food results. Proceed to the next environmental medium or click the Calculate Total Risk/Hazard Report button.

The food medium is not available in VURAM's screening levels module. Quantitative risk assessment for food is available for the residential study area only. For non-residential study areas requiring evaluation of the food medium re-run VURAM as residential and evaluate food only, submit both reports with the risk assessment.

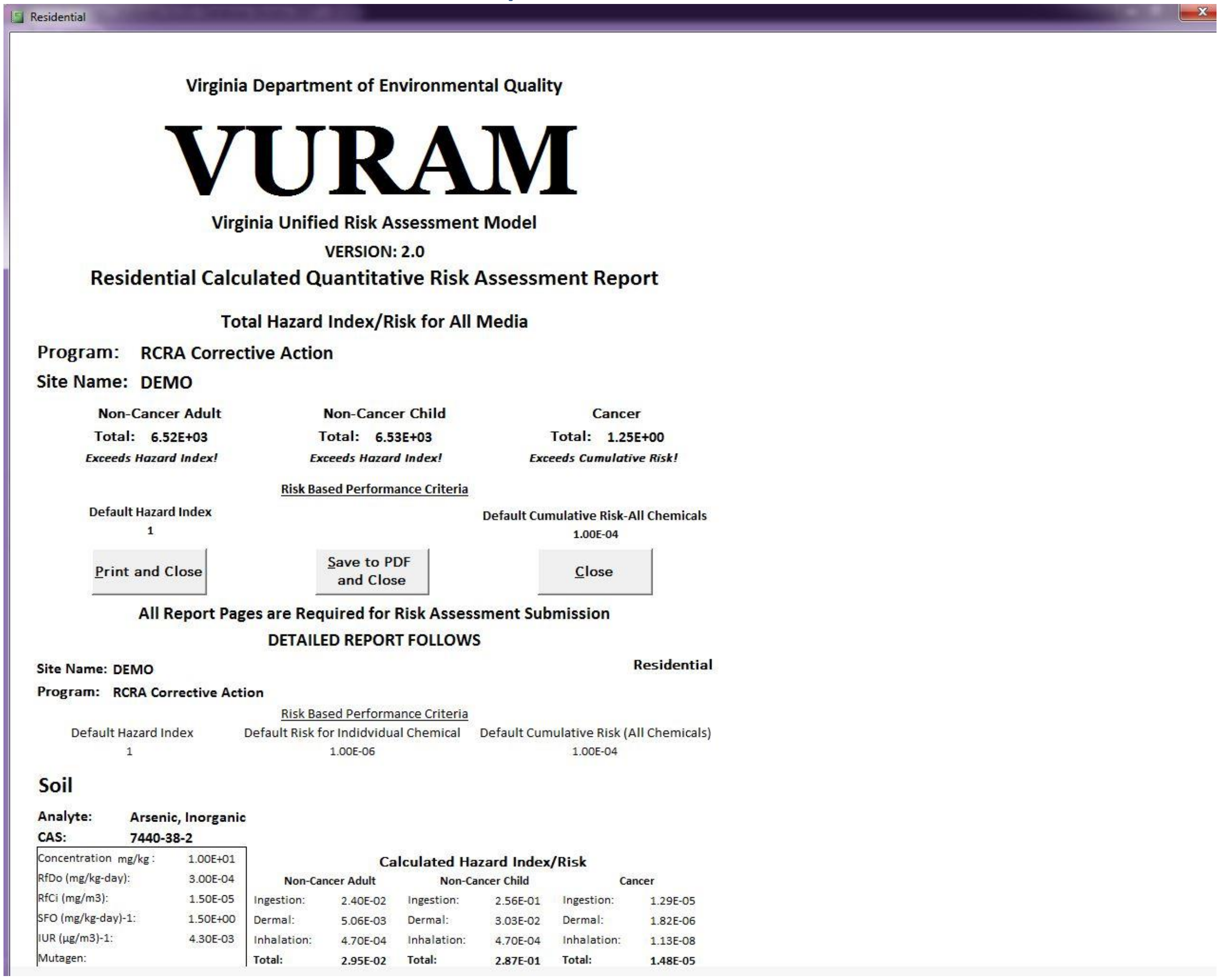
IMPORTANT! Select at least one food group to evaluate the food medium; all selections must have entered concentrations for all selected COPCs.

2.7.3g Unavailable Environmental Media



When an environmental medium is not available for calculation due to a program or study area restriction, the page controls will appear gray and unresponsive. The environmental media, tabs and the Quit, Go Back and Calculate Total Risk/Hazard Report buttons are still functional. However, the report calculation will only function if all inputs on all other environmental media tabs are completed.

2.7.4 Quantitative Risk Assessment Report


Residential

Virginia Department of Environmental Quality

VURAM

Virginia Unified Risk Assessment Model

VERSION: 2.0

Residential Calculated Quantitative Risk Assessment Report

Total Hazard Index/Risk for All Media

Program: RCRA Corrective Action

Site Name: DEMO

Non-Cancer Adult	Non-Cancer Child	Cancer
Total: 6.52E+03	Total: 6.53E+03	Total: 1.25E+00
Exceeds Hazard Index!	*Exceeds Hazard Index!*	*Exceeds Cumulative Risk!*

Risk Based Performance Criteria

Default Hazard Index 1

Default Cumulative Risk-All Chemicals 1.00E-04

Print and Close | Save to PDF and Close | Close

All Report Pages are Required for Risk Assessment Submission

DETAILED REPORT FOLLOWS

Site Name: DEMO Residential

Program: RCRA Corrective Action

Risk Based Performance Criteria

Default Hazard Index	Default Risk for Indidvidual Chemical	Default Cumulative Risk (All Chemicals)
1	1.00E-06	1.00E-04

Soil

Analyte: Arsenic, Inorganic

CAS: 7440-38-2

Concentration mg/kg:	1.00E+01
RfDo (mg/kg-day):	3.00E-04
RfCi (mg/m3):	1.50E-05
SFO (mg/kg-day)-1:	1.50E+00
IUR (µg/m3)-1:	4.30E-03
Mutagen:	

Calculated Hazard Index/Risk

Non-Cancer Adult		Non-Cancer Child		Cancer	
Ingestion:	2.40E-02	Ingestion:	2.56E-01	Ingestion:	1.29E-05
Dermal:	5.06E-03	Dermal:	3.03E-02	Dermal:	1.82E-06
Inhalation:	4.70E-04	Inhalation:	4.70E-04	Inhalation:	1.13E-08
Total:	2.95E-02	Total:	2.87E-01	Total:	1.48E-05

The Report View in MS Access allows for printing and saving functions to appear as buttons on the report. The report will display as a single contiguous page. Print layouts are setup in the report and page headers and footers will be repeated automatically.

The Total Hazard/Risk Report is broken down by selected media and by chemical. A total (site wide) hazard for adult and child (if applicable) and risk is calculated by summing the hazard/risk respectively from all chemicals and all exposure pathways across all media. Individual hazard/risk levels are given for each selected chemical and each applicable exposure pathway where all values necessary for computation are available. Chemicals without computed hazard/risk values do not have associated values within VURAM and are reported as blank. VURAM does not compute uncertainty. However, blank values must be included in the qualitative uncertainty discussion section of the Risk Assessment report.

Changes to the risk assessment can be made as needed by closing the report and returning to the Calculations Page. To run a new risk assessment, under same or different regulatory program, **Close** the report and return to the Setup page. A report for each evaluated study area must be included in the final Human Health Risk Assessment report submitted to Virginia DEQ for review and approval.

ALERT! Save or Print the report before exiting the Media Calculation Page. Screening reports are **NOT** saved in VURAM.

2.7.4a Title Page

Virginia Department of Environmental Quality

VURAM

Virginia Unified Risk Assessment Model

VERSION: 2.0

Residential Calculated Quantitative Risk Assessment Report

Total Hazard Index/Risk for All Media

Program: RCRA Corrective Action

Site Name: DEMO

Non-Cancer Adult	Non-Cancer Child	Cancer
Total: 6.52E+03	Total: 6.53E+03	Total: 1.25E+00
Exceeds Hazard Index!	***Exceeds Hazard Index!***	***Exceeds Cumulative Risk!***

Risk Based Performance Criteria

Default Hazard Index	Default Cumulative Risk-All Chemicals
1	1.00E-04

All Report Pages are Required for Risk Assessment Submission

DETAILED REPORT FOLLOWS

Monday, March 12, 2018 Page 1 of 24

The report title page identifies the VURAM version, selected regulatory program, site name, total (site-wide) hazard/risk and the risk-based performance criteria. If the study area is construction then the report includes groundwater contact depth.

Where HI/HQ or risk exceeds the risk-based performance criteria an exceeds message is displayed next to the total.

IMPORTANT! All pages are required for submission.

2.7.4b Detailed Section

Site Name: DEMO | Residential
Program: RCRA Corrective Action

Risk Based Performance Criteria

Default Hazard Index	Default Risk for Indidvidual Chemical	Default Cumulative Risk (All Chemicals)
1	1.00E-06	1.00E-04

Soil

Analyte: Arsenic, Inorganic
CAS: 7440-38-2

Concentration mg/kg :	1.00E+01
RfDo (mg/kg-day):	3.00E-04
RfCi (mg/m3):	1.50E-05
SFO (mg/kg-day)-1:	1.50E+00
IUR (µg/m3)-1:	4.30E-03
Mutagen:	
VOC:	

Calculated Hazard Index/Risk

Non-Cancer Adult		Non-Cancer Child		Cancer	
Ingestion:	2.40E-02	Ingestion:	2.56E-01	Ingestion:	1.29E-05
Dermal:	5.06E-03	Dermal:	3.03E-02	Dermal:	1.82E-06
Inhalation:	4.70E-04	Inhalation:	4.70E-04	Inhalation:	1.13E-08
Total:	**2.95E-02**	**Total:**	**2.87E-01**	**Total:**	**1.48E-05**
% Contribution to Media Hazard/Risk	1.11%		6.77%		2.91%

Exceeds Risk! mg/kg	*Non-Cancer Adult*	*Non-Cancer Child*	*Cancer*
Recommended Acceptable Concentration	*N/A*	*N/A*	*6.77E-01*

Analyte: Benzene
CAS: 71-43-2

Concentration mg/kg :	1.00E+01
RfDo (mg/kg-day):	4.00E-03
RfCi (mg/m3):	3.00E-02
SFO (mg/kg-day)-1:	5.50E-02
IUR (µg/m3)-1:	7.80E-06
Mutagen:	
VOC:	Y

Calculated Hazard Index/Risk

Non-Cancer Adult		Non-Cancer Child		Cancer	
Ingestion:	3.00E-03	Ingestion:	3.20E-02	Ingestion:	7.91E-07
Dermal:		Dermal:		Dermal:	
Inhalation:	9.04E-02	Inhalation:	9.04E-02	Inhalation:	7.86E-06
Total:	**9.34E-02**	**Total:**	**1.22E-01**	**Total:**	**8.65E-06**
% Contribution to Media Hazard/Risk	3.52%		2.89%		1.70%

Exceeds Risk! mg/kg	*Non-Cancer Adult*	*Non-Cancer Child*	*Cancer*
Recommended Acceptable Concentration	*N/A*	*N/A*	*1.16E+00*

Analyte: Benzo[a]pyrene
CAS: 50-32-8

Concentration mg/kg :	1.00E+01
RfDo (mg/kg-day):	3.00E-04
RfCi (mg/m3):	2.00E-06
SFO (mg/kg-day)-1:	1.00E+00
IUR (µg/m3)-1:	6.00E-04
Mutagen:	Y
VOC:	

Calculated Hazard Index/Risk

Non-Cancer Adult		Non-Cancer Child		Cancer	
Ingestion:	4.00E-02	Ingestion:	4.26E-01	Ingestion:	6.53E-05
Dermal:	2.19E-02	Dermal:	1.31E-01	Dermal:	2.18E-05
Inhalation:	3.53E-03	Inhalation:	3.53E-03	Inhalation:	4.35E-09
Total:	**6.54E-02**	**Total:**	**5.61E-01**	**Total:**	**8.71E-05**
% Contribution to Media Hazard/Risk	2.47%		13.26%		17.15%

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The detailed report section header shows site-specific information from the title page and risk- based performance criteria. VURAM computes a hazard/risk value for each entered COPC at the entered concentration provided all parameters for computation are available. The analyte summary table includes the entered concentration and analyte toxicity information. Hazard/risk values are broken down by exposure pathway and hazard calculations are reported by receptor. A percent contribution to medium hazard/risk is computed for each analyte total. For residential and industrial study areas, a calculated recommended acceptable concentration is provided in the same that indicates if the COPC hazard/risk value exceeds the risk-based performance criteria.

IMPORTANT! If using the recommended acceptable concentration to set clean up goals select the lowest value to meet risk-based performance criteria for the COPC in the applicable medium. Values may be considered a final clean-up goal for human health. Values are based on the available site-specific data.

Site Name: QRA | Residential
Program: RCRA Corrective Action

Risk Based Performance Criteria

Default Hazard Index	Default Risk for Indidvidual Chemical	Default Cumulative Risk (All Chemicals)
1	1.00E-06	1.00E-04

Groundwater

Total Calculated Hazard/Risk For Media: Groundwater

Non-Cancer Adult		Non-Cancer Child		Cancer	
Ingestion:	8.34E+00	Ingestion:	1.39E+01	Ingestion:	5.18E-03
Dermal:	1.54E+02	Dermal:	2.32E+02	Dermal:	1.14E-02
Inhalation:	1.64E+02	Inhalation:	1.64E+02	Inhalation:	6.38E-04
Total:	**3.26E+02**	**Total:**	**4.10E+02**	**Total:**	**1.72E-02**

Each environmental media is sumerized for calculated hazard/risk totals for each exposure pathway and overall total for the medium. Totals are calculated by summing the exposure pathway values for each noncancer receptor (adult/child) and cancer (lifetime) column respectively.

Site Name: DEMO | Residential
Program: RCRA Corrective Action

Risk Based Performance Criteria

Default Hazard Index	Default Risk for Indidvidual Chemical	Default Cumulative Risk (All Chemicals)
1	1.00E-06	1.00E-04

Food

Analyte: Arsenic, Inorganic
CAS: 7440-38-2

Concentration mg/kg :	
RfDo (mg/kg-day):	3.00E-04
RfCi (mg/m3):	1.50E-05
SFO (mg/kg-day)-1:	1.50E+00
IUR (µg/m3)-1:	4.30E-03
Mutagen:	
VOC:	

Calculated Hazard Index/Risk

Non-Cancer Adult		Non-Cancer Child		Cancer	
Ingestion:	2.42E+02	Ingestion:	2.42E+02	Ingestion:	4.05E-02
Dermal:		Dermal:		Dermal:	
Inhalation:		Inhalation:		Inhalation:	
Total:	**2.42E+02**	**Total:**	**2.42E+02**	**Total:**	**4.05E-02**
% Contribution to Media Hazard/Risk	25.48%		25.48%		10.85%

Exceeds Hazard! Exceeds Risk!	mg/kg *Non-Cancer Adult*	*Non-Cancer Child*	*Cancer*
Recommended Acceptable Concentration	*See Detailed Food Report*	*See Detailed Food Report*	*See Detailed Food Report*

Some differences in the report exist for the food medium. A separate Detailed Food Report is included when food is evaluated. Analyte concentration is NOT included in the COPC summary table, as different food groups (meat and dairy, eggs, fish and shellfish, and fruits and vegetables) may have different concentrations. See the Detailed Food Report section for concentrations in each selected food group. Toxicity information is still included. Hazard/risk levels values reflect the sum all selected food groups. The detailed residential food report section is only available if the food medium is calculated; otherwise a note stating this page intentionally left blank is displayed.

Site Name: DEMO | Residential

Program: RCRA Corrective Action

Risk Based Performance Criteria

Default Hazard Index	Default Risk for Indidvidual Chemical	Default Cumulative Risk (All Chemicals)
1	1.00E-06	1.00E-04

Detailed Residential Food Report

Analyte: Arsenic, Inorganic

CAS: 7440-38-2

Concentrations	(mg/kg)
Meat/Dairy:	10
Eggs:	10
Fish/Shellfish:	10
Fruits/Vegetables:	10

Calculated Hazard/Risk Values

Non-Cancer		Cancer	
Meat/Dairy:	1.12E+02	Meat/Dairy:	1.87E-02
Eggs:	5.99E+01	Eggs:	1.00E-02
Fish/Shellfish:	2.16E+01	Fish/Shellfish:	3.61E-03
Fruits/Vegetables:	4.87E+01	Fruits/Vegetables:	8.15E-03
Total:	**2.42E+02**	**Total:**	**4.05E-02**
% Contribution to Media Risk	*25.48%*		*10.85%*

Recommended Acceptable Concentrations		*Meat/Dairy*	*Eggs*	*Fish/Shellfish*	*Fruits/Vegetables*
Exceeds Hazard!	*Non-Cancer*	*8.94E-02*	*1.67E-01*	*4.63E-01*	*2.05E-01*
Exceeds Risk!	*Cancer*	*5.35E-04*	*9.98E-04*	*2.77E-03*	*1.23E-03*

Analyte: Benzene

CAS: 71-43-2

Concentrations	(mg/kg)
Meat/Dairy:	10
Eggs:	10
Fish/Shellfish:	10
Fruits/Vegetables:	10

Calculated Hazard/Risk Values

Non-Cancer		Cancer	
Meat/Dairy:	8.39E+00	Meat/Dairy:	6.86E-04
Eggs:	4.49E+00	Eggs:	3.67E-04
Fish/Shellfish:	1.62E+00	Fish/Shellfish:	1.32E-04
Fruits/Vegetables:	3.66E+00	Fruits/Vegetables:	2.99E-04
Total:	**1.82E+01**	**Total:**	**1.48E-03**
% Contribution to Media Risk	*1.91%*		*0.40%*

Recommended Acceptable Concentrations		*Meat/Dairy*	*Eggs*	*Fish/Shellfish*	*Fruits/Vegetables*
Exceeds Hazard!	*Non-Cancer*	*1.19E+00*	*2.22E+00*	*6.18E+00*	*2.74E+00*
Exceeds Risk!	*Cancer*	*1.46E-02*	*2.72E-02*	*7.56E-02*	*3.35E-02*

Analyte: Benzo[a]pyrene

CAS: 50-32-8

Concentrations	(mg/kg)
Meat/Dairy:	10
Eggs:	10
Fish/Shellfish:	10
Fruits/Vegetables:	10

Calculated Hazard/Risk Values

Non-Cancer		Cancer	
Meat/Dairy:	1.12E+02	Meat/Dairy:	1.25E-02
Eggs:	5.99E+01	Eggs:	6.68E-03
Fish/Shellfish:	2.16E+01	Fish/Shellfish:	2.40E-03
Fruits/Vegetables:	4.87E+01	Fruits/Vegetables:	5.43E-03
Total:	**2.42E+02**	**Total:**	**2.70E-02**
% Contribution to Media Risk	*25.48%*		*7.23%*

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The detailed residential food report section is very similar to the detailed report section with minor differences to accommodate multiple food groups. Analyte concentrations for each selected food group (meat and dairy, eggs, fish and shellfish, and fruits and vegetables) are displayed in the analyte table. If a Food Group is not selected, concentration will be blank. The only exposure pathway evaluated for food is ingestion. Calculated hazard/risk values for each selected food group are reported and then totaled for the overall hazard/risk for each analyte. Noncancer values are irrespective of age. However, noncancer values add to both adult and child receptor totals on the main report. Recommended acceptable concentrations are computed for each evaluated food group.

Total Hazard/Risk For Media: Detailed Food

Non-Cancer		Cancer	
Meat and Dairy:	4.39E+02	Meat and Dairy:	1.72E-01
Eggs:	2.35E+02	Eggs:	9.23E-02
Fish and Shellfish:	8.47E+01	Fish and Shellfish:	3.32E-02
Fruits and Vegetables:	1.91E+02	Fruits and Vegetables:	7.51E-02
Total:	**9.50E+02**	**Total:**	**3.73E-01**

Food media totals reflect the sum for all analytes and all selected food groups, and the value is reported on the main report at the end of the detailed food report section and following the food medium in the detailed report section.

2.7.4d Report Summary

Site Name: **DEMO** **Residential**

Program: **RCRA Corrective Action**

Risk Based Performance Criteria

Default Hazard Index	Default Risk for Indidvidual Chemical	Default Cumulative Risk (All Chemicals)
1	1.00E-06	1.00E-04

Total Hazard Index/Risk for All Media

Non-Cancer Adult		**Non-Cancer Child**		**Cancer**	
Ingestion:	9.54E+02	Ingestion:	9.58E+02	Ingestion:	3.76E-01
Dermal:	2.30E+01	Dermal:	3.48E+01	Dermal:	1.03E-02
Inhalation:	5.54E+03	Inhalation:	5.54E+03	Inhalation:	8.66E-01
Total:	**6.52E+03**	**Total:**	**6.53E+03**	**Total:**	**1.25E+00**
Exceeds Hazard Index!		***Exceeds Hazard Index!***		***Exceeds Cumulative Risk!***	

The report summary computes the sum of the hazard/risk values from all COPCs across all environmental media. These totals are also displayed on the Title Page.

Site Name: DEMO Residential

Program: RCRA Corrective Action

Risk Based Performance Criteria

Default Hazard Index	Default Risk for Indidvidual Chemical	Default Cumulative Risk (All Chemicals)
1	1.00E-06	1.00E-04

Residential Exposure Default Values

Symbol	Description	Value	Units
AFres-a	Resident Soil Adherence Factor - adult	0.07	(mg/cm2)
AFres-c	Resident Soil Adherence Factor - child	0.2	(mg/cm2)
ATres	Resident Averaging Time: 365 x LT	25550	(days)
ATres-a	Resident Averaging Time - adult: 365 x EDres-a	9490	(days)
ATres-c	Resident Averaging Time - child: 365 x EDres-c	2190	(days)

[...]

IRSres-a	Resident Soil Ingestion Rate - adult	100	(mg/day)
IRSres-c	Resident Soil Ingestion Rate - child	200	(mg/day)
IRWres-a	Resident Drinking Groundwater Ingestion Rate - adult	2.5	(L/day)
IRWres-c	Resident Drinking Groundwater Ingestion Rate - child	0.78	(L/day)
SAres-a	Resident Soil Surface Area - adult	6032	(cm2/day)
SAres-a	Resident Water Surface Area - adult	19652	(cm2)
SAres-c	Resident Soil Surface Area - child	2373	(cm2/day)
SAres-c	Resident Water Surface Area - child	6365	(cm2)

END OF REPORT

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The summary includes all exposure defaults for the selected study area for all environmental media regardless of computation. These values are also available for view in VURAM on the Standard Defaults Page. An end of report message is displayed after the exposure defaults list.

2.8 Media Concentration Pages

Media concentration pages are available under both RCRA and VRP programs in the screening levels module and for all programs in quantitative risk assessment module. These pages offer multiple methods of navigating through the selected analytes for data entry of concentration values, but do not allow edits to the analyte names or CAS numbers. Air and surface water pages differ between the screening vs. quantitative risk assessment modules. The food medium is not available in VURAM's screening levels module.

IMPORTANT! Analyte concentrations must be entered in the **UNITS OF MEASUREMENT** specified for each medium! Conversion of units may be required before data entry.

IMPORTANT! For screening, use the maximum concentration for each medium as the exposure concentration for a given pathway, to place an upper bound on exposure (RAGS Part A). For non-detects, use ½ of the method detection limit. In cases where the method detection limit exceeds screening values, contact a DEQ project manager or risk assessor.

IMPORTANT! For quantitative risk assessment, the EPC for a given medium is either the maximum detected concentration or the 95% upper confidence limit of the mean.

Each page contains an anayte and CAS display and a text box for entering concentration data. First, Back, Forward, and Last buttons are included for navigation between analytes. A table of all medium-specific analytes is displayed below the data entry section. This chemical list is reflective of the selection of medium-specific COPCs from the previous page. The table may be used to select an analyte for data entry.

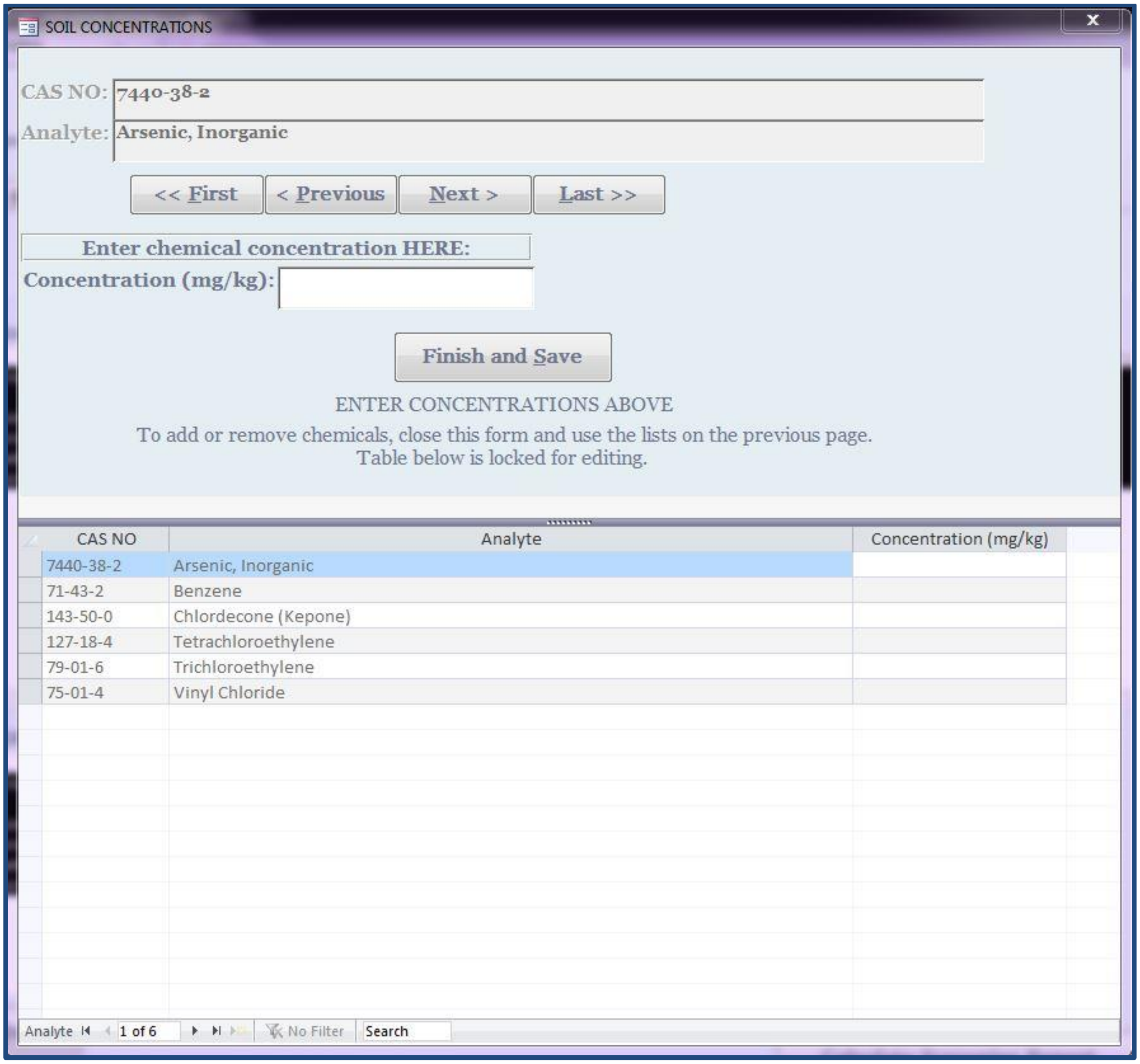
Enter sampled or modeled concentrations as appropriate into the concentration entry text. All concentrations must be positive and greater than zero. Scientific notation (e.g., 1.23E-5) or decimal notation (e.g.,0.000123) is permitted for data entry. After a concentration is entered, either the tab or enter key will proceed to the next analyte.

After entering concentrations for an environmental medium, click the Finish and Save button to return to the screening or calculation page and proceed with calculations. Then continue to next environmental medium or the report. Finish and Save will not work if concentration entry is incomplete. To close the environmental medium concentration page and return to the list of analytes, use the red X navigation in the upper right hand corner of the page. Entered concentrations will remain in VURAM's memory unless the analyte is removed from the medium-specific list. If an analyte has no data, close the concentrations page and remove it from the medium list on the previous page.

NOTE: The last value entered in the concentrations list does not display in the table until a different analyte has been selected. After entering the last concentration in the list, click Finish and Save to continue.

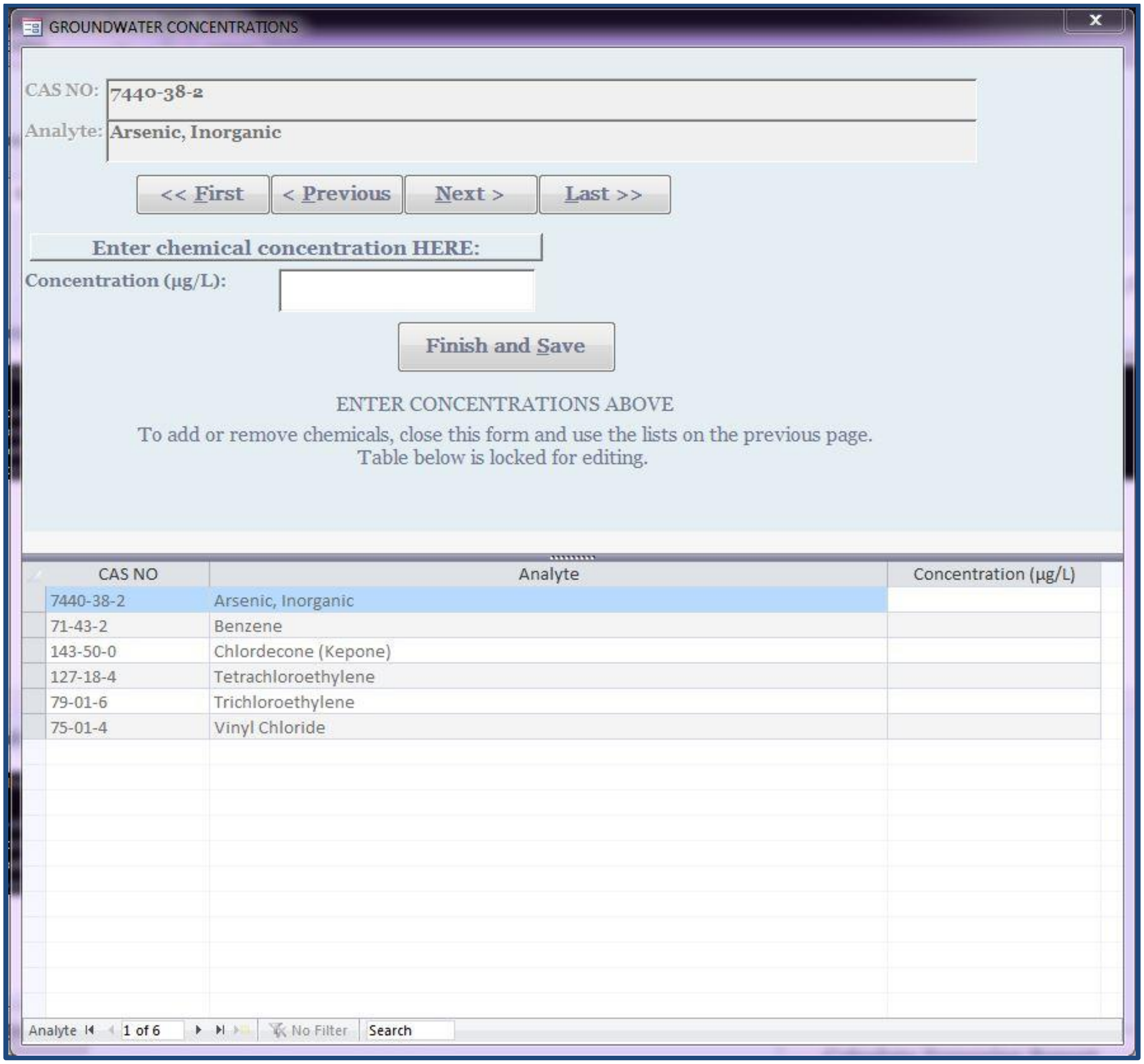
ALERT! Concentrations must be saved via the Finish and Save button to proceed with screening or calculations.

2.8.1 Soil Concentrations



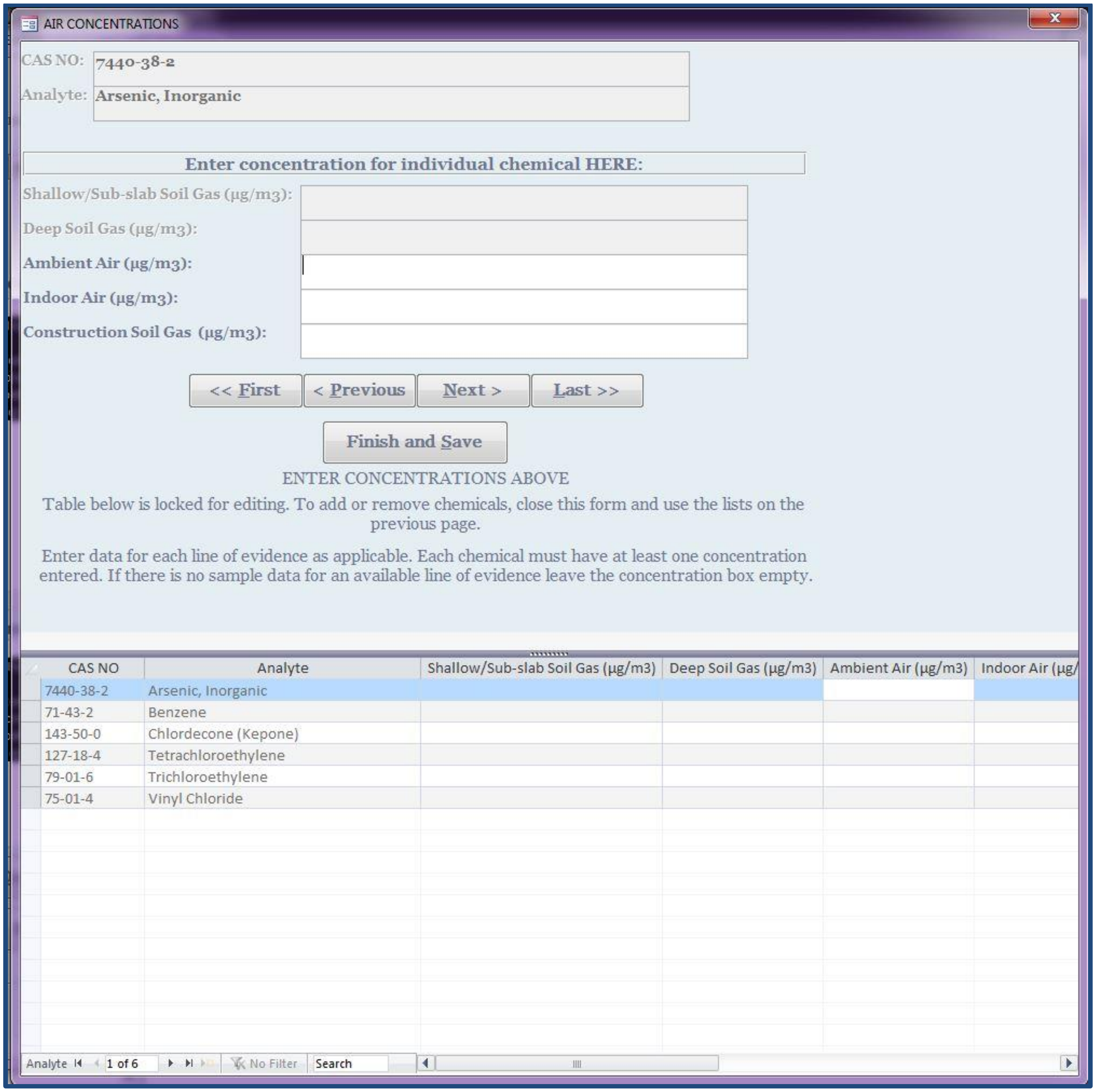
The concentration page for soil is the same for screening and quantitative risk assessment. Enter a concentration for each analyte in the concentration entry field. Click Finish and Save to continue. Soil concentration units are mg/kg.

2.8.2 Groundwater Concentrations

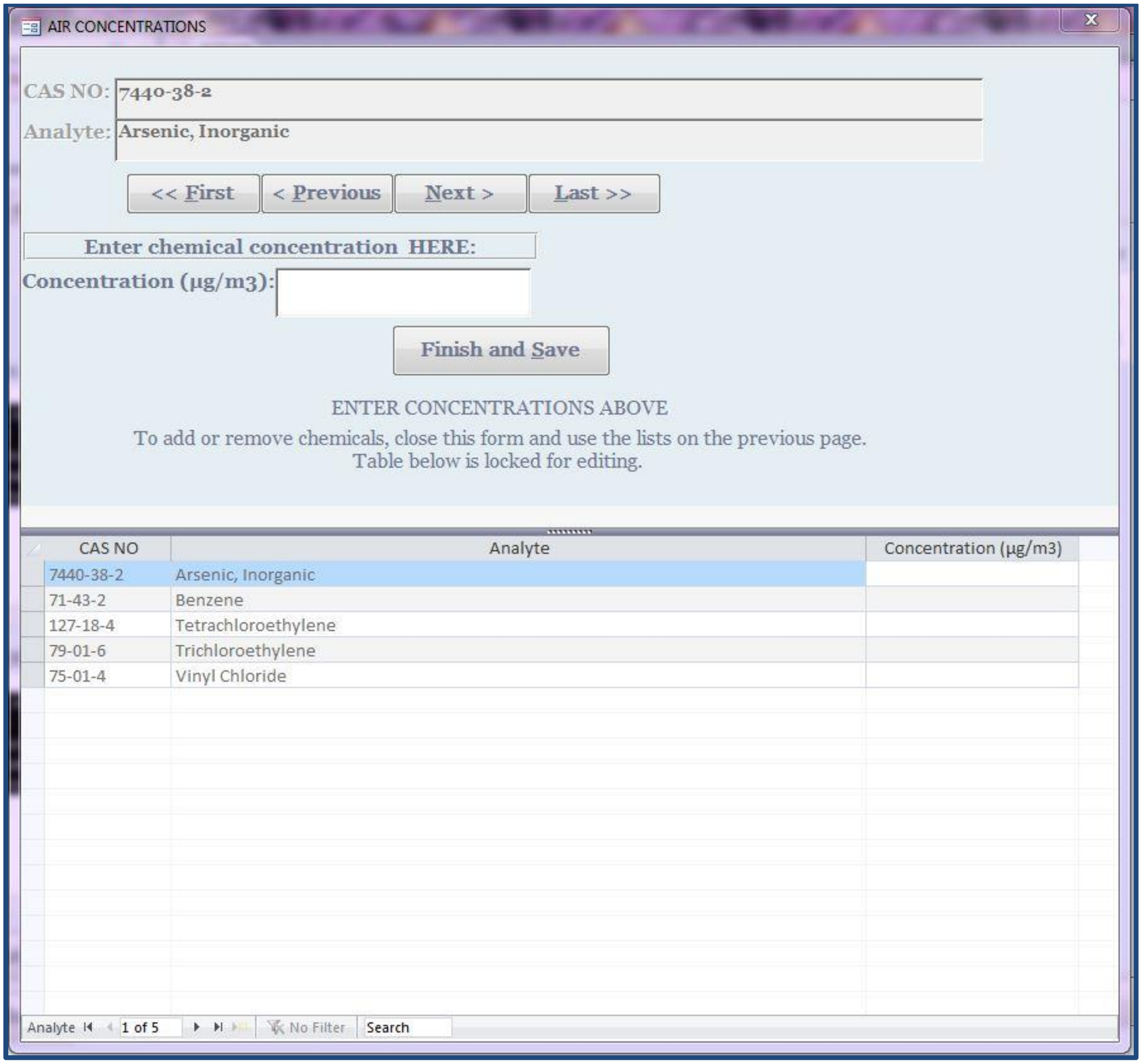


The concentration page for groundwater is the same for screening and quantitative risk assessment. Enter a concentration for each analyte in the concentration entry field. Click Finish and Save to continue. Groundwater concentration units are µg/L.

2.8.3 Air Concentrations



The air concentrations page differs between the screening levels and the quantitative risk assessment modules. The screening levels module allows entry of concentrations from samples associated with different segments of the air/vapor intrusion exposure pathways, i.e., air, soil gas (or subslab gas) potentially migrating to indoor air, and soil gas potentially migrating to trench air. These options must be selected on the prior (screening) page, and only the selected options will appear available on the concentrations page. Enter all applicable concentrations for each analyte in the concentration entry field. (At least one concentration must be entered for each analyte). Click Finish and Save to contiue. Air concentration units are µg/m³.



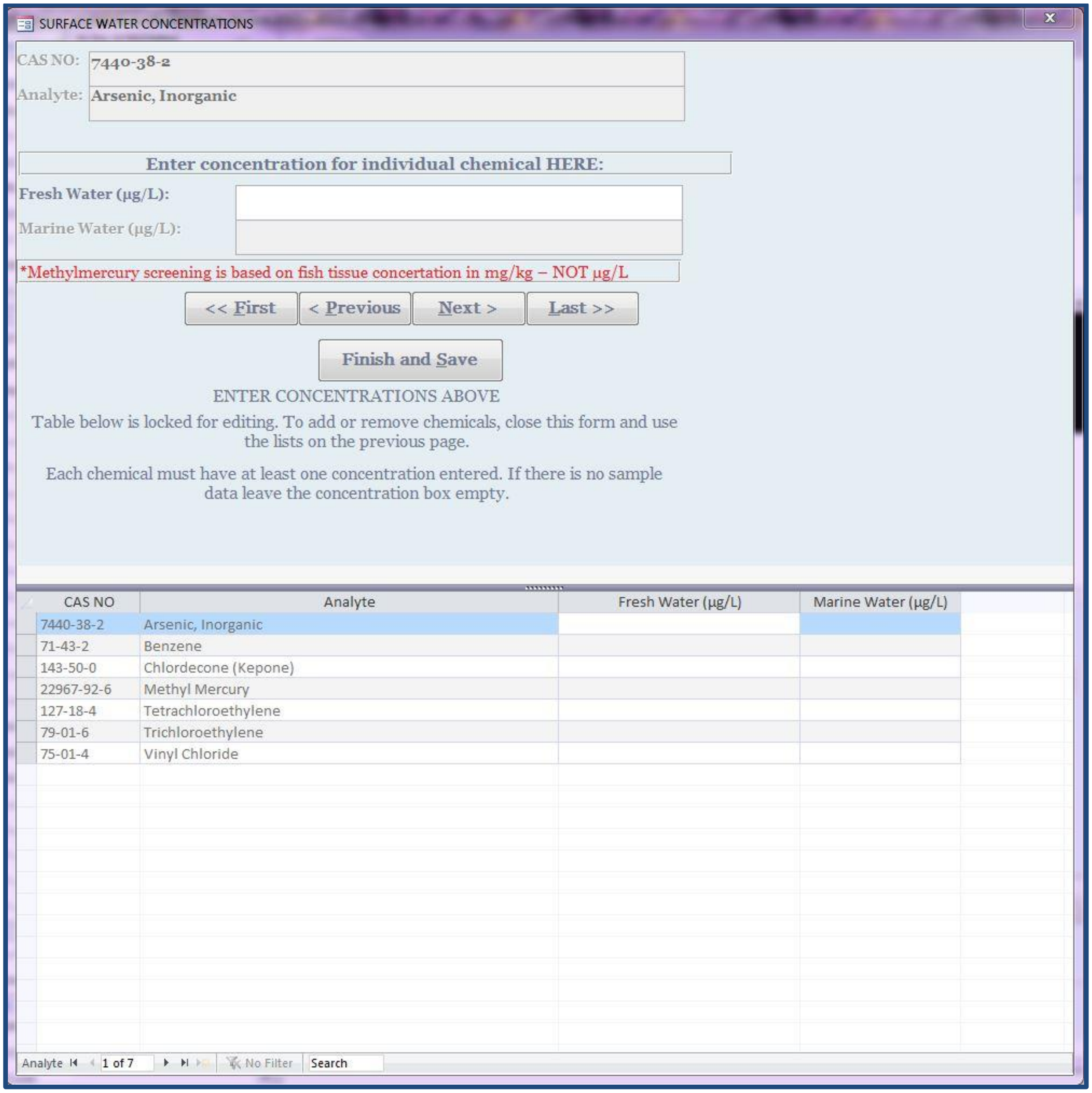
For quantitative risk assessment, air hazard/risk values are computed using indoor air equations for residential and industrial study areas. To convert groundwater or soil gas concentrations to estimated indoor air concentrations, refer to EPA's VISL calculator.

IMPORTANT! Use the concentration which shows the maximum exceedance of screening levels.

Enter concentrations for each analyte in the concentration entry field. Click Finish and Save to continue. Air concentration units are µg/m³.

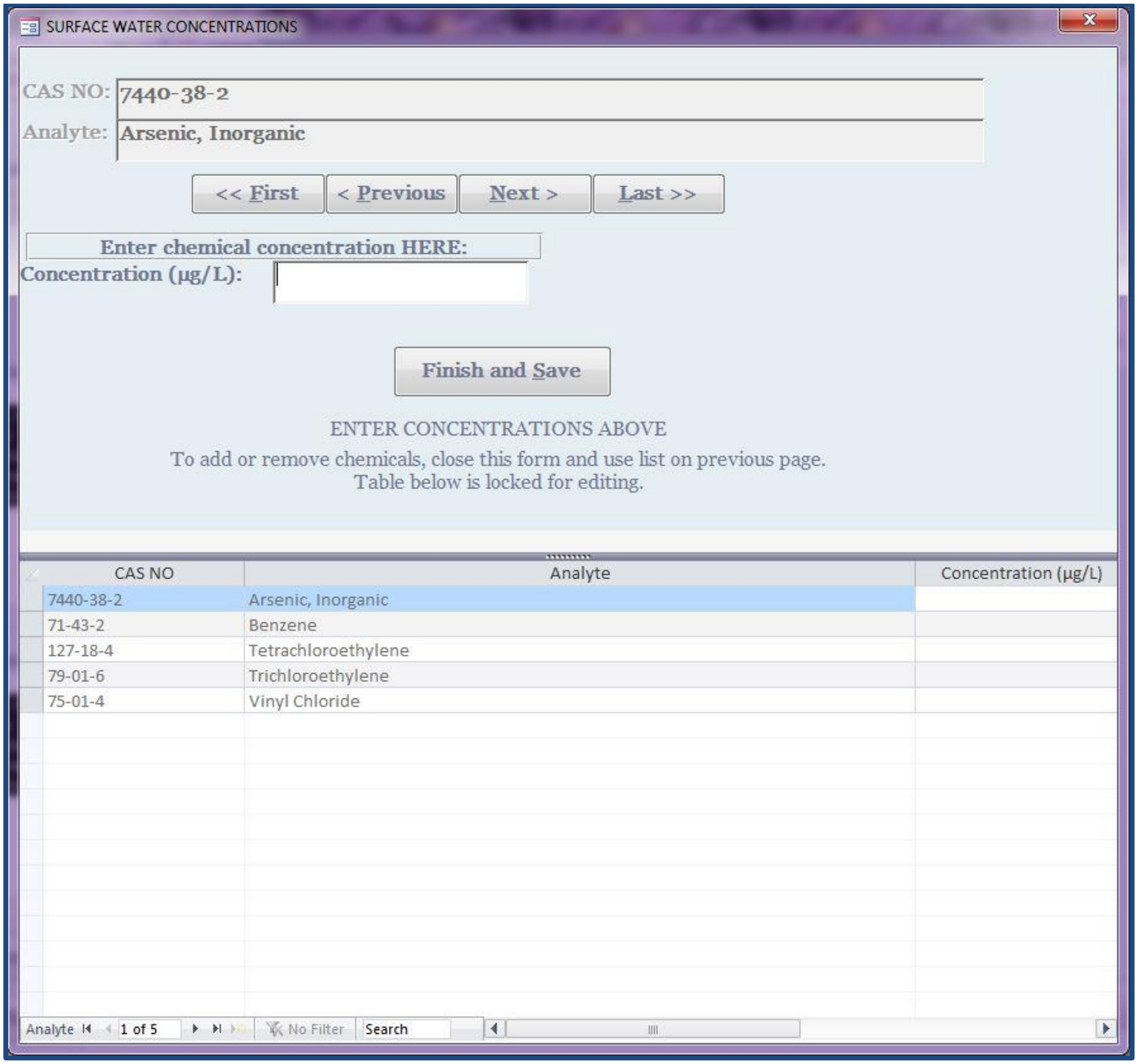
NOTE: The construction study area is calculated using the DEQ Construction Worker Trench Model for soil gas.

2.8.4 Surface Water Concentrations



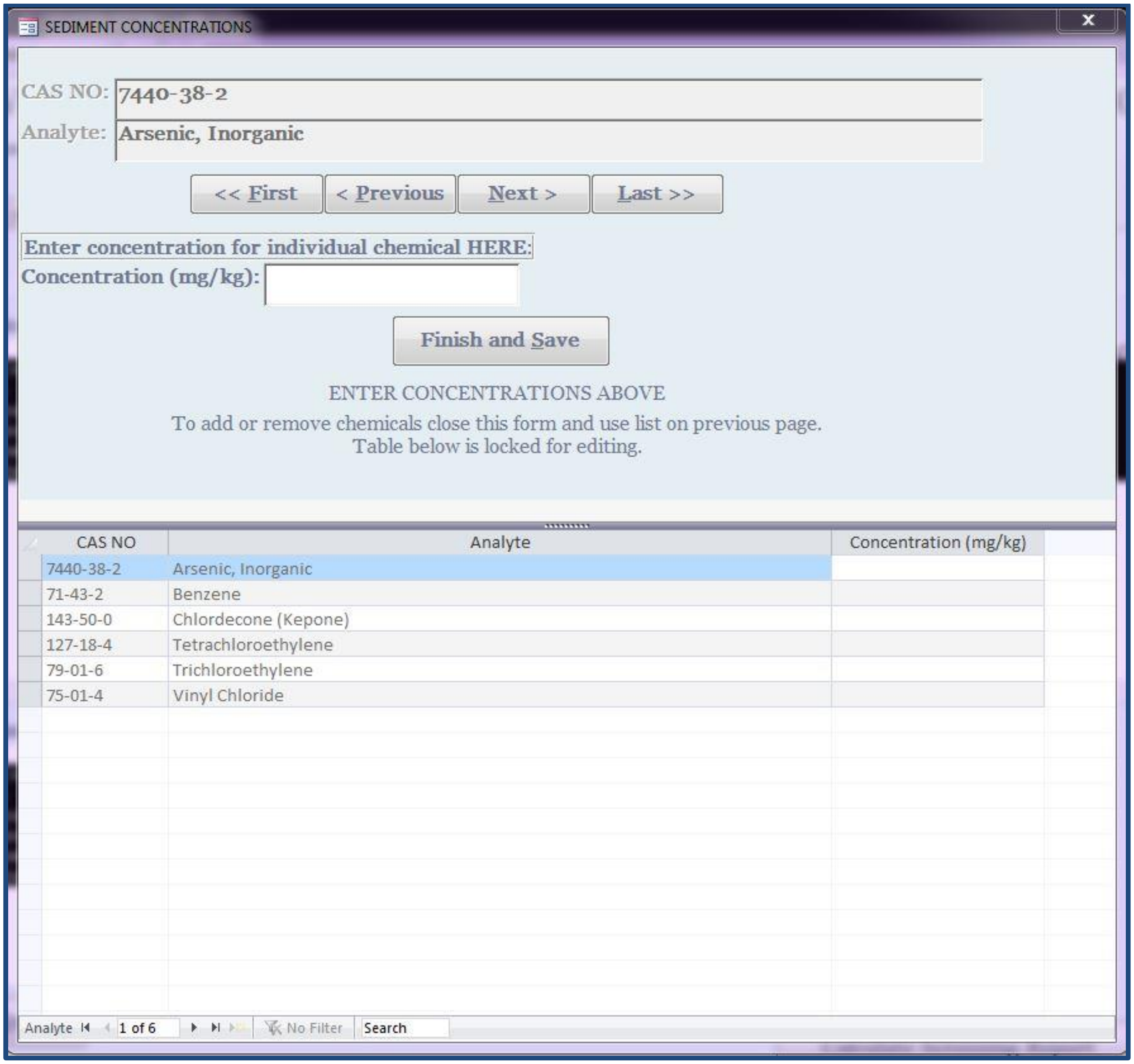
Surface water concentrations page differs between screening and quantitative risk assessment modules. For screening fresh and/or marine water based on the CSM, at least one concentration must be entered for each analyte. Enter applicable concentrations for each analyte in the concentration entry field. Click Finish and Save to continue. Surface water concentration units (µg/L).

IMPORTANT! If methylmercury, CAS 22967-92-6, is selected in surface water screening, enter concentrations for methylmercury in mg/kg based on fish tissue criterion.



Quantitative evaluation of surface water is calculated on EPA RSL recreator equations and is not dependent on fresh/marine water. Enter concentrations for each analyte in the concentration entry field. Click Finish and Save to continue. Surface water concentration units are µg/L.

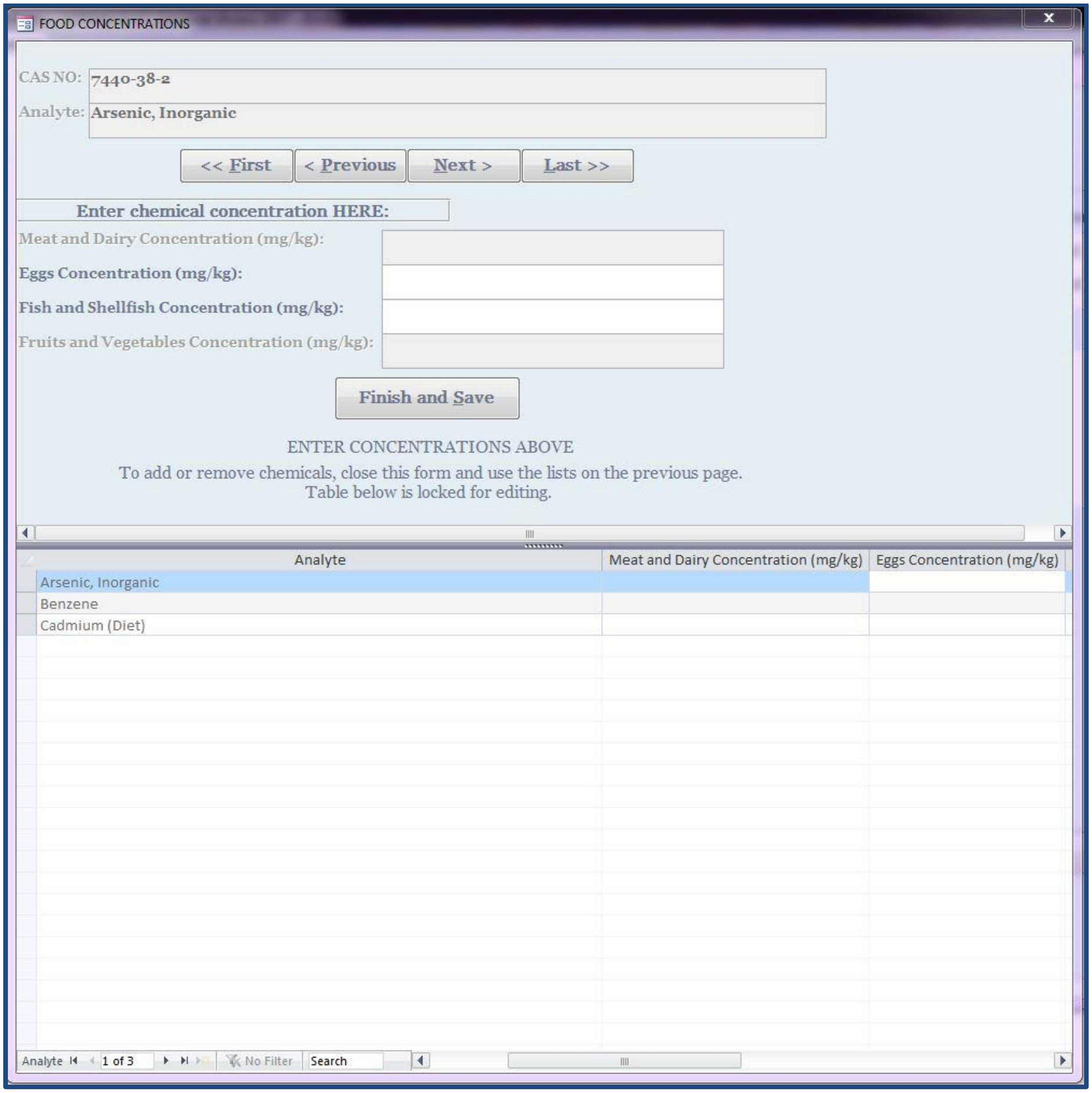
2.8.5 Sediment



The concentration page for sediment is the same for screening and quantitative risk assessment. Enter concentrations for each analyte in the concentration entry field. Click Finish and Save to continue. Sediment concentration units are mg/kg.

Sediment screening is only applicable under VRP and is not available under RCRA Corrective Action. However, hazard/risk values for sediment can be evaluated quantitatively under RCRA for applicable study areas.

2.8.6 Food



The food medium is not available in the screening levels module. Enter concentrations for each analyte in the concentration entry field. All selected food groups are available for entry of concentrations. All analytes must have concentrations for all selected food groups to proceed. Food concentration units are mg/kg. Click Finish and Save to continue.

2.9 Site-Specific Background Comparison Module

Background sampling is conducted to distinguish site-related contamination from naturally occurring or other non-site-related levels of chemicals. Background comparison is not risk assessment. However, for inorganic constituents (mostly metals), Virginia DEQ highly recommends collecting site- or unit-specific natural background data. The background comparison module for inorganics is included in VURAM to conduct background concentration comparisons. This module can be used as Tier I under the VRP and

Brownfields programs. The CERCLA and Federal Facilities Programs may have a different approach than presented here. Hence, Virginia DEQ strongly recommends contacting the project manager and risk assessor to finalize the appropriate use of site-specific background screening. Refer to Risk Assessment Guidance for Superfund (RAGS Part A) and Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites for details on obtaining site-specific background concentrations.

This evaluation includes only inorganic constituents that are naturally occurring. Site-specific background provides the best data to estimate if a release from the site activities has occurred. The use of literature-based background values to eliminate COPCs from further discussions and evaluations is not appropriate. If COPCs are below site-specific background **AND** the evaluation meets Virginia DEQ's approval, then these COPCs may be removed from further screening.

IMPORTANT! Site-specific background concentrations **MUST** be accepted by DEQ prior to submission.

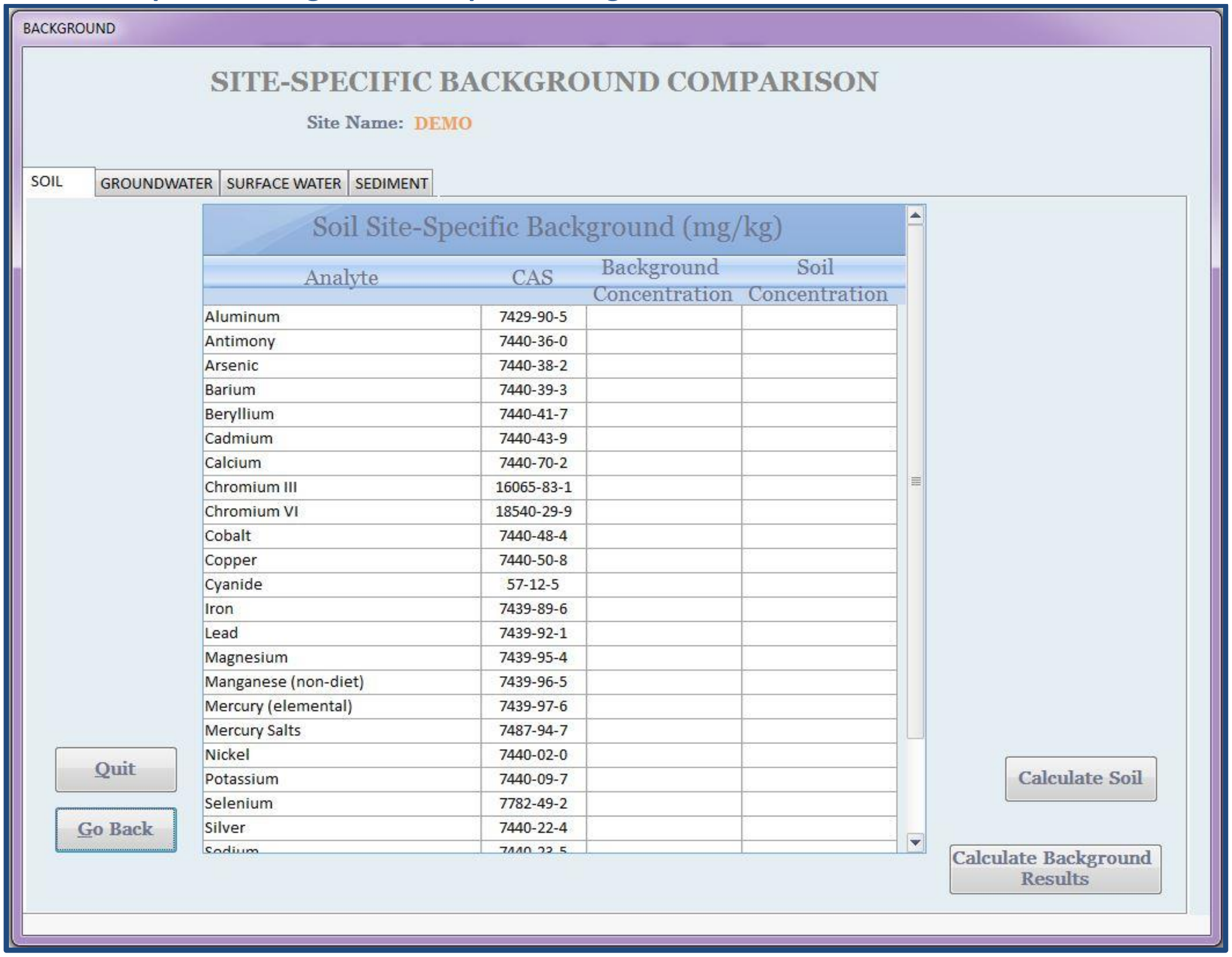
IMPORTANT! Virginia DEQ considers background data only for naturally occurring inorganics and not for organic and anthropogenic chemicals.

Collect background samples from nearby areas that have not been affected by the site-related activities or releases. An upgradient location may not be an appropriate background location due to potential unknown upgradient sources. Therefore, selection of background location may require some time and effort. This module provides list of all the COPCs to be included. If the site-specific background comparison is based on site-specific historical information, discuss a shorter list of COPCs for consideration with DEQ project manager and risk assessor. **DO NOT** exclude inorganics from screening or assume that they are part of background concentrations based only on literature review. Enter all analyzed inorganics, site-specific background concentrations, and medium-specific concentrations to conduct a comparison. If the medium-specific concentrations are greater than site-specific background concentrations, then those analytes are COPCs to be included in quantitative risk assessment.

Maximum COPC concentrations from the site for all media of concern are compared to 95% UTL (upper tolerance limit) of site-specific background concentrations. Conducting background sampling, evaluating, and approving background values is outside the scope of this VURAM User Guide. Contact project manager for detailed discussions prior to collecting background samples and using VURAM's Site-Specific Background Comparison Module.

IMPORTANT! Include the report from this module along with the Screening Report if an inorganic constituent is eliminated from quantitative risk assessment based on site-specific background comparison.

2.9.1 Site-Specific Background Comparison Page



The site-specific background comparison page provides the table of inorganics (mostly metals) to be evaluated for site-specific background comparison. Enter both the background concentration at 95% UTL and the maximum sampled environmental medium concentration for all analytes in each sampled environmental media to be included in the background comparison.

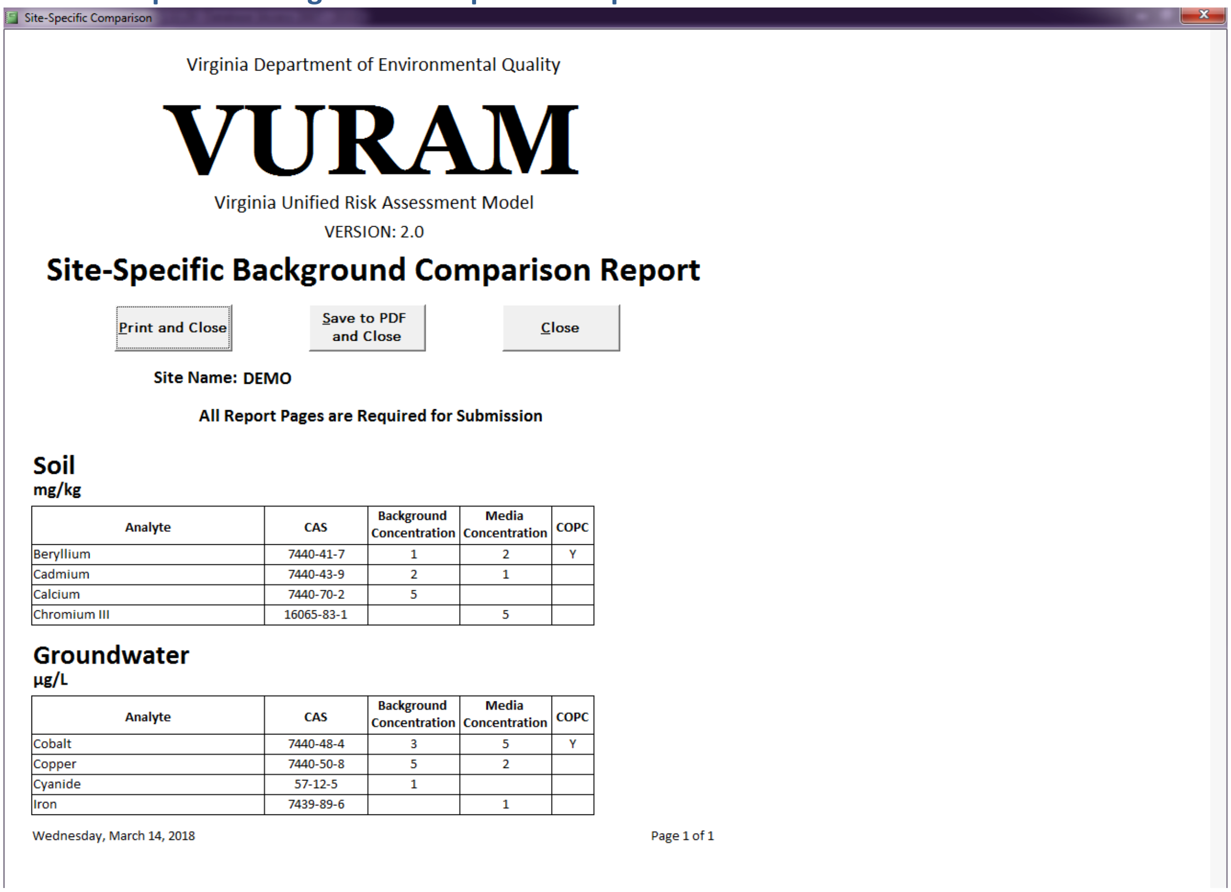
IMPORTANT! Maximum COPC concentrations from the site for all media of concern are compared to 95% UTL (upper tolerance limit) of site-specific background concentrations.

IMPORTANT! Analyte concentration **UNITS** must be entered in the **UNITS OF MEASUREMENT** specified for each medium! Conversion of units may be required before data entry.

After entering concentrations for the selected medium, click the Calculate Medium button to compare the background for that medium. A green check mark and label will appear across the bottom of the screening page to indicate the completed medium. Any changes to concentrations will cause the medium label and check mark to disappear, indicating that the medium has not been reevaluated with the changes. Once concentrations are entered for a given medium, the screening comparison for that medium must be completed to proceed with the report. A red X icon will be displayed next to areas which have not been completed. Continue to next environmental medium or click the Calculate Background Results button if ready to proceed to the results report. To quit VURAM and return to the

Background Page, click Quit. To return to the Introduction page to conduct screening or quantitative risk assessment, click Go Back.

2.9.2 Site-Specific Background Comparison Report



Site-Specific Comparison

Virginia Department of Environmental Quality

VURAM

Virginia Unified Risk Assessment Model

VERSION: 2.0

Site-Specific Background Comparison Report

Print and Close | Save to PDF and Close | Close

Site Name: DEMO

All Report Pages are Required for Submission

Soil

mg/kg

Analyte	CAS	Background Concentration	Media Concentration	COPC
Beryllium	7440-41-7	1	2	Y
Cadmium	7440-43-9	2	1	
Calcium	7440-70-2	5		
Chromium III	16065-83-1		5	

Groundwater

µg/L

Analyte	CAS	Background Concentration	Media Concentration	COPC
Cobalt	7440-48-4	3	5	Y
Copper	7440-50-8	5	2	
Cyanide	57-12-5	1		
Iron	7439-89-6		1	

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The Report View in MS Access allows for printing and saving functions to appear as buttons on the report. The report will display as a single contiguous page. Print layouts are setup in the report and page headers and footers will be repeated automatically.

The report results are grouped by environmental media. Each medium's analyte concentration is compared to the entered background concentration. The COPC column displays a "Y" if the analyte concentration exceeds background and is left blank if the analyte concentration does not exceed background. Only analytes with entered data reported will be evaluated. For a valid report, all evaluated analytes must have appropriate background and sampled concentrations entered.

Changes to the concentrations can be made as needed by closing the report and returning to the Site-Specific Background Comparisons Page.

ALERT! Save or Print the report before exiting the Site-Specific Background Comparisons Page! Reports are **NOT** saved in VURAM.

IMPORTANT! Do not exclude inorganics from screening prior to conducting a background comparison. Include the Site-Specific Background Comparison Report for chemicals eliminated from quantitative risk assessment based on background levels.

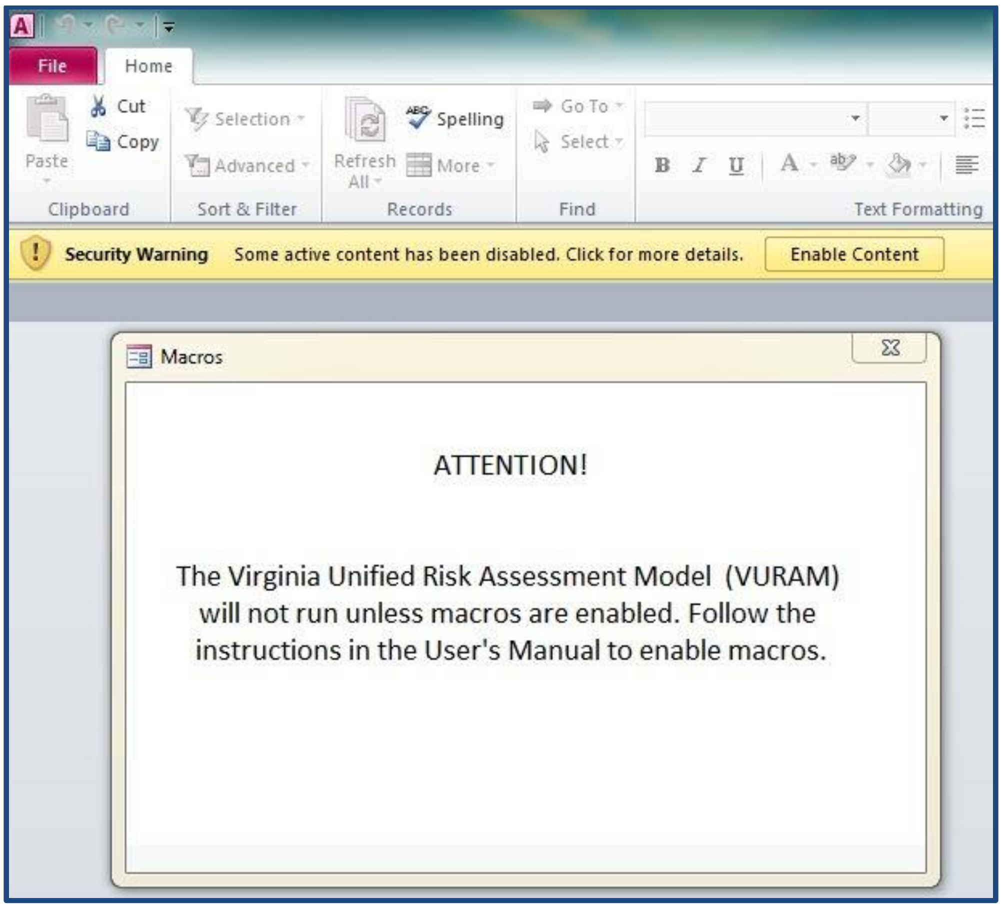
2.10 FAQ - Troubleshooting Common Errors

Included are common problems encountered when running VURAM. If problem persists, notify Virginia DEQ VURAM staff.

ALERT! For stable performance, always run VURAM from a local drive. Network or shared drive locations can impair database performance or cause the program calculations to fail.

2.10.1 Security warning VURAM does not auto-start:

If the database is not trusted by MS Access (or in a trusted location) then a security warning is displayed. The image below is MS Access 2010, other versions of MS Access may have a different version of this message.



To run VURAM, click **Enable Content.** To prevent this message on subsequent runs of VURAM, follow the MS Access instructions for adding the database to a trusted location, or make it a trusted document.

2.10.2 Error message when attempting to proceed:

Several data entry validation checks are made between pages to ensure that all processes required for computation are complete. Check all tabs on the page for red X icons and ensure all selections have been made and all fields have data entered.

2.10.3 Pages do not fit the monitor:

MS Access does not automatically accommodate screen resolution. Individual monitors may change the appearance of the pages of VURAM. All pages, except the VURAM Background Page, can be moved, sized, and scrolled. The page size can be adjusted using standard mouse navigation to move and size each page excluding the VURAM Background Page.

2.10.4 VURAM is running very slow:

Ensure that VURAM is saved to and running from a local drive before using. The VURAM database is not designed to be run over a network. Slow performance is expected when VURAM is operating from a network location. Opening multiple instances of VURAM from a network location can cause model failure or file corruption. If multiple module runs of VURAM have been conducted without closing VURAM, then database performance may slow. Close VURAM and re-open to clear working memory. If file corruption is suspected, delete the file and download a new copy from the Virginia DEQ Risk Assessment webpage.

ALERT! Force-quitting MS Access while VURAM is open can cause database corruption. Wait for MS Access to completely close before attempting any actions, including re-opening, copying, moving or deleting the VURAM file.

2.10.5 Not all selected analytes included in risk assessment:

MS Access limits the total number of characters that can be added to the COPCs List for screening and the COPCs List for quantitative risk assessment. For risk assessments which exceed the limit (usually greater than 200 analytes), multiple runs of VURAM may be necessary to analyze all chemicals included in the CSM. Include all reports in the risk assessment submission and note that each report is a partial analyte list for the site.

2.10.6 Report display blank or will not scroll

Sometimes the reports will fail to display when first opened. Try clicking or scrolling to load the report content. If the report still does not display as expected, close the report via the Windows Navigation Controls (red X in the upper right hand corner of the report) and recalculate the report. No data will be lost, as long as the report-calling page is not closed.

2.10.7 VURAM seems to be broken:

Unexpected behavior or system error messages can occur in and with MS Access. Most commonly database corruption is due to the interruption of the MS Access shut down process. If corruption of the VURAM file is suspected, delete the file and download a new copy from the Virginia DEQ Risk Assessment webpage. If the problem persists, notify Virginia DEQ VURAM staff.

2.10.8 VURAM will not run on Mac:

The VURAM database application is not compatible with MS Office for Mac.

3.0 Modeling Approach

Risk assessment is to the highest extent possible, a scientific process. See EPA's About Risk Assessment webpage for a basic overview of risk assessment. The ultimate purpose of all risk assessment is to develop risk-based cleanup goals that protect human health and the environment, and restore the environment to the extent practicable. Risk assessment provides information on potential health or ecological risks, while risk management is the actions taken based on consideration of risk assessment and other information, which includes, but is not limited to, other scientific information, economic factors, social factors, laws, and regulations. Risk assessment in VURAM follows a logical flow approach to screening and quantitative risk assessment calculations based on site-specific chemical lists, study area characteristics, and human exposure-related criteria to establish risk-based cleanup standards for contaminated soil, groundwater, air, surface water, sediment, and food. Calculated outputs from VURAM iform risk and project management decision making process under different regulatory mechanisms. Virginia DEQ programs have different requirements and risk management options, yet risk assessment models for each of these programs rely on similar input parameters and calculation algorithms.

3.1 Virginia DEQ Programs

Virginia DEQ’s Division of Land Protection and Revitalization is responsible for carrying out the mandates of the Virginia Waste Management Act and meeting the Commonwealth of Virginia's obligations under RCRA and CERCLA. Virginia DEQ’s Division of Land Protection and Revitalization administers several programs designed to ensure that the cleanup of contaminated sites in the Commonwealth to achieve a satisfactory level of human health and environmental protection. Virginia DEQ also has statutory authority to administer the VRP and Brownfields Land Renewal Program, and the RCRA Groundwater Corrective Action Program. Human and ecological risk assessments are conducted to ensure that the cleanups and risk management decisions adequately protect human health and environment.

All of the following regulatory programs, at various stages of operation (i.e., closure, post closure care, remedial decision making and/or corrective action activities), may need to perform a human health risk assessment in order to demonstrate that risks posed by contaminants attributed to a facility are within acceptable limits, thereby protecting public health, the environment, and the natural resources of the Commonwealth.

Cleanup standards are implemented as remedial action goals for the cleanup-based programs. The focus of the cleanup process is on assessing all sites for current and potential future risk to human health, and choosing cleanup levels using risk-based information. Different cleanup levels will be appropriate in different situations. Cleanup levels are best established as site-specific goals and as part of the cleanup and remedial action selection process. Public and private sector investigators have recognized the need for a systematic and scientifically valid process to aid in managing risk associated with exposure to environmental contaminants; a consistent approach to developing cleanup goals will expedite decisions concerning protection of public health.

3.1.1 RCRA Hazardous Waste Permitting and Corrective Action

EPA’s hazardous waste permitting program, established by RCRA, helps ensure the safe treatment, storage, and disposal of hazardous wastes by establishing specific requirements that must be followed when managing hazardous wastes. RCRA Subtitle C establishes a federal program to manage hazardous wastes from cradle to grave. Permits for the treatment, storage, or disposal of hazardous wastes are issued by authorized states, including the Commonwealth of Virginia, or by EPA regional offices. Permits include applicable EPA regulations from the CFR Title 40 parts 260 through 270 and subparts.

Human health and ecological risk assessments are an integral part of risk-based closure of permitted units as well as a tool for evaluating operating permits for Subparts O and H for waste combustion units and Subpart X facilities. Past risk assessment pertaining to RCRA permitted facilities, including closures in conjunction with Virginia DEQ’s Risk-Based Closure Guidance, was conducted using "Guidance for development of health-based cleanup goals using decision tree/REAMS program November 1, 1994 and subsequent updates as prepared by Old Dominion University developed by DEQ" (Virginia DEQ, 1994). While the overall approach and assumptions provided in DEQ's Risk-Based Closure Guidance and Risk Exposure and Analysis Modeling System (REAMS) manual remain valid and applicable. VURAM replaces and supersedes the risk assessment module of the REAMS software but does **NOT** replace the fate and transport modules of REAMS. In places where risk assessment assumptions are conflicting between REAMS and VURAM, VURAM will supersede. VURAM will be used for conducting risk characterization at permitted units.

For facilities that have releases of hazardous waste or constituents into soil, groundwater, surface water, and/or air, EPA and authorized states and territories, including the Commonwealth of Virginia, work with responsible facilities to investigate and clean up hazardous releases under RCRA Corrective Action. The RCRA Corrective Action program is a result of HSWA passed by Congress, which required the cleanup of contamination from improper waste management practices both prior to and after the passage of RCRA. The statute requires responsible parties that are seeking a permit to treat, store, or dispose of hazardous wastes to clean up environmental contaminants at their sites regardless of the time of release. EPA's Corrective Action authority was substantially expanded by HSWA, allowing the agency to address any releases of hazardous waste or hazardous waste constituents to all environmental media at both RCRA permitted and non-permitted facilities. Human health and ecological risk assessment is an integral part of the RCRA Corrective Action site cleanup process. The RCRA Corrective Action program may conduct risk assessment to assess baseline risk, establish cleanup levels, evaluate the effectiveness of remedial measures, and decide the end of cleanup activities. The Risk Assessment Guidance for RCRA Corrective Action can be found on the Virginia DEQ website. VURAM will be used for conducting risk characterization at these facilities.

3.1.2 CERCLA (Superfund)

CERCLA, commonly known as Superfund, became law in December 1980 and establishes a program to identify sites from which releases of hazardous substances into the environment might occur or have already occurred, and to respond to abandoned sites and/or sites where the owner or operator went bankrupt. EPA administers the Superfund program in Virginia and DEQ performs necessary activities mandated by the Superfund law. DEQ is not involved in day-to-day activities of Superfund sites. However, VURAM may be used as a reference at these sites in Virginia as VURAM reflects calculation assumptions and algorithms in the federal facilities program. VURAM calculations may be used as a reference at these sites. Due to the scale and complexity of these sites, the use of VURAM for facilities under the CERCLA process is dependent on approval from EPA/Virginia DEQ project manager.

3.1.3 Federal Facilities under CERCLA

Federal Facilities that are significantly contaminated may be listed on the National Priorities List (NPL). CERCLA Section 120 requires federal agencies with NPL sites to investigate and clean up the contamination. DEQ is authorized to conduct regulatory oversight of environmental investigation, remediation, and restoration projects at federal facilities in Virginia. For this program, consult RAGS Part A. VURAM reflects calculation assumptions and algorithms in CERCLA risk assessment evaluation. VURAM calculations may be used as a reference at these sites. Due to the scale and complexity of these sites the use of VURAM for Federal Facilities is dependent on approval from Virginia DEQ/EPA project manager.

3.1.4 RCRA Subtitle D - Solid Waste

This program focuses on state and local governments as the primary planning, regulating, and implementing entities for the management of non-hazardous solid waste, such as household garbage and non-hazardous industrial solid waste. Virginia DEQ is responsible for administering the regulations governing the management of solid waste in the Commonwealth. The VSWMR governs solid waste management facilities. Under the VSWMR, solid waste management facilities include, but are not limited to, landfills; including sanitary landfills, industrial waste landfills, and construction and demolition debris landfills. Pursuant to VSWMR, these facilities may be required to monitor groundwater. The risk assessment guidance for the Solid Waste Program can be found at Virginia DEQ's Risk Assessment for Solid Waste webpage. VURAM will be used for conducting risk characterization at these facilities.

3.1.5 Brownfields and VRP

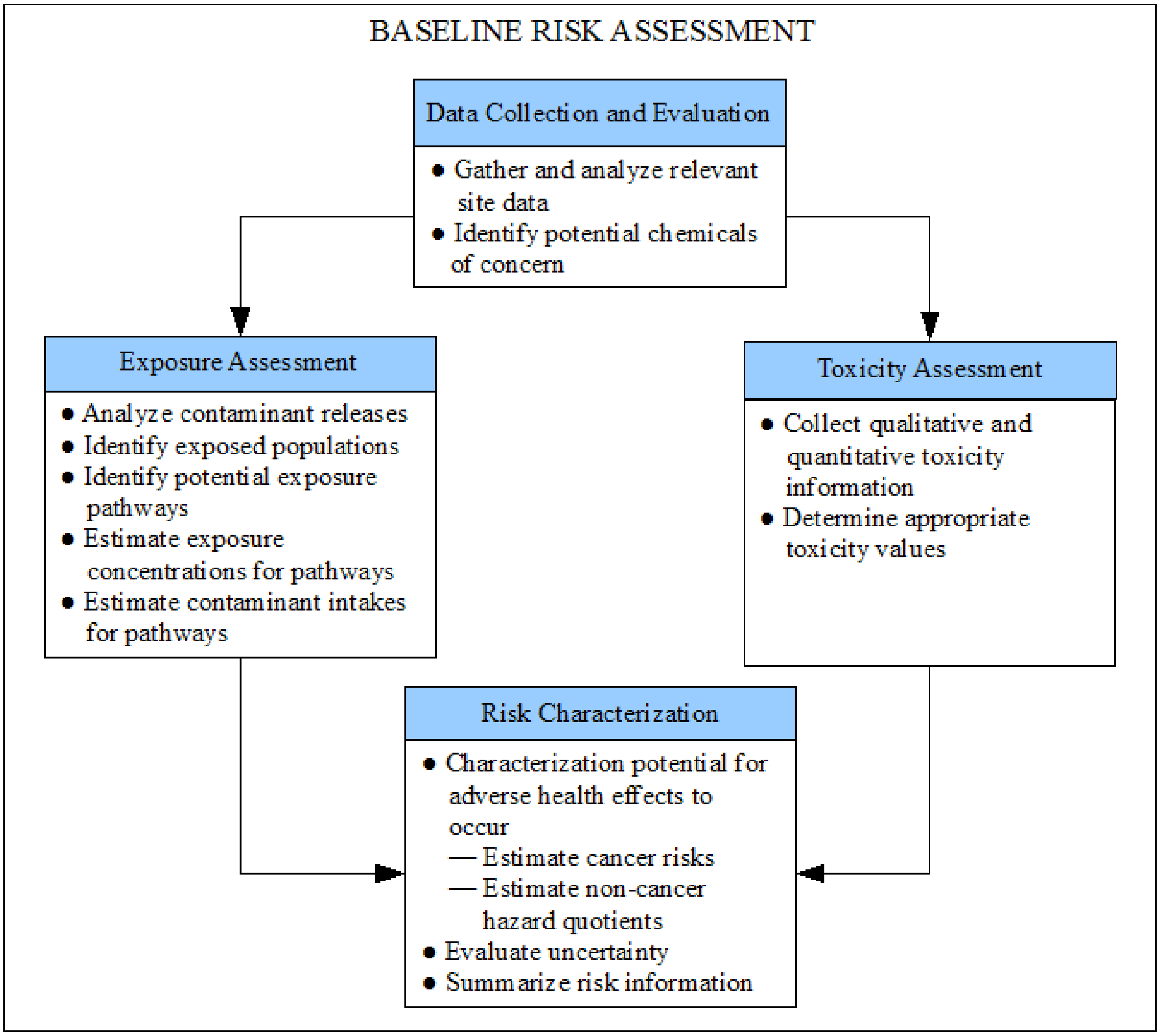
The Code of Virginia §10.1-1231, "Brownfield restoration and Land Renewal Policy and Programs" states, "It shall be the policy of the Commonwealth to encourage remediation and restoration of brownfields by removing barriers and providing incentives and assistance whenever possible." The purpose of the VRP is to encourage hazardous substance cleanups that might not otherwise take place. The regulatory basis for performing risk assessments under the Virginia VRP is found in the Voluntary Remediation Regulations Section, 9 VAC 20-160-70(A)(1)(a).

The risk assessment will include an evaluation of the risks to human health and the environment posed by the release or threatened release of contaminants into the environment. If the risk assessment shows that a removal or other remedial action is necessary then a proposed set of remediation levels as described in Section 9 VAC 20-160-90 will also be included. Note that certain exposure assumptions and considerations of this program, such as the use of institutional controls to remove receptors from further consideration in the risk assessment, do not apply to other regulatory programs. For guidance on how presumptive remedies can influence risk assessment, refer the VRP Risk Assessment Guidance.

VURAM replaces and supersedes several of the interactive MS Excel-based risk assessment tables previously provided on DEQ's VRP website. The VRP Risk Assessment Guidance can be found at Virginia DEQ website. VURAM will be used for conducting risk characterization at these facilities.

3.2 Risk Assessment Process

Virginia DEQ follows the 4-step risk paradigm outlined in RAGS Part A and EPA RSL User's Guide: data collection and evaluation, exposure assessment, toxicity assessment, and risk characterization. These steps are depicted in the figure below and are adopted from Risk Assessment Guidance for Superfund, Human Health Evaluation Manual, Part A, Interim Final.



Data collection and evaluation are performed to acquire the necessary data from environmental media to identify COPCs and support the calculation of EPCs in the exposure assessment. The purpose and scope of a risk assessment are based on the regulatory program's needs, which dictate data quality objectives and data quality assurance plans. Once objectives are decided, media sampling is conducted to develop an understanding of the nature and extent of chemical contamination in the environment and to predict how the contaminants may behave in the future. Data collection and evaluation rely heavily on the CSM to identify which environmental media should be sampled and at which locations.

An exposure pathway describes how a receptor may come into contact with a chemical source via an exposure route—ingestion, inhalation, and/or dermal. Site data provide an estimate of medium-specific EPCs for receptors identified in the CSM. Chemical intake (also known as the dose) is calculated as a function of the concentration of the chemical in an environmental medium and the characteristics and behaviors of the potentially exposed receptors. Land use assumptions and exposure factors are an important part of these calculations.

The toxicity assessment integrates data from published animal and human studies to identify adverse health effects, which may be caused by exposure to the COPCs, and the dose at which harmful health effects may occur. Harmful effects are broadly categorized as either carcinogenic or noncarcinogenic.

The toxicity assessment is integrated with the exposure assessment to quantify potential health risks. The risk characterization reveals which COPCs pose the most significant risks and which exposure pathways are important. VURAM reflects only this last step in the risk assessment process.

3.3 Modeling Parameters and Data Sources

The primary source for all VURAM chemical parameters, toxicity values, and exposure default values is EPA RSL. RSL screening values are computed using toxicity values and standard exposure scenarios to determine chemical concentrations corresponding to a fixed level of risk. These values are considered to be protective for humans, including sensitive groups, over a lifetime. However, they do not combine risk across various media and/or contaminants, are not always applicable to a particular site, and do not address non-human health endpoints, such as ecological impacts. Additional chemical parameter values may be obtained through the source documentation based on the toxicity hierarchy.

The RSL table is updated semiannually as new toxicological data are published. Risk assessments are required to use the most recent update of the RSL table available at the time of data analysis and to note the date of the RSL table. VURAM relies on the EPA RSL table to update toxicity and chemical properties. EPA RSL User's Guide (EPA, 2017c) provides primary sources of chronic and subchronic toxicity values as follows in the order of preference and hierarchy:

- EPA's Integrated Risk Information System (IRIS)
- Provisional Peer Reviewed Toxicity Values for Superfund (PPRTV)
- The Agency for Toxic Substances and Disease Registry (ATSDR) minimal risk levels (MRLs)
- Office of Environmental Health Hazard Assessment's (OEHHA) Chronic Reference Exposure Levels (chRELs) as of June 2014
- Technical Support Document for Cancer Potency Factors 2009
- Consolidated Table of OEHHA/ARB Approved Risk Assessment Health Values
- Decision Making at Contaminated Sites: Issues and Options in Human Health Risk Assessment: Appendix A
- Health Effects Assessment Summary Tables (HEAST): FY 1997 Update

The RSL table is a risk-based screening for CERCLA/Superfund, RCRA Corrective Action, and Federal Facility sites. While RSL refers to the Superfund program, Virginia DEQ follows the same risk assessment approach for RCRA and VRP programs. Therefore, RSL remains applicable to regulatory programs covered in VURAM. For exposure default cases where EPA RSL recommends site-specific values, Virginia DEQ values are selected and noted. For recreator and trespasser physical considerations (e.g., body weight and surface area), EPA RSL residential values are selected for consistency. The Industrial/Commercial scenario uses the composite worker defaults. A full list of exposure defaults used in VURAM is located in appendix A1.0.

For the construction worker study area, subchronic toxicity values are obtained via the EPA RSL calculator. These values are not published with the RSL tables or in the RSL User's Guide (EPA, 2017c), but can be obtained through downloading the metadata provided via the RSL calculator. Construction groundwater and soil gas (air) media for the construction worker scenario in both screening and quantitative risk assessment are computed using the Virginia DEQ Construction Worker Trench Model located in appendix A2.0.

The Chemical Abstracts Service issues a unique numerical identifier to every chemical substance described in the open scientific literature. Chemical names in VURAM generally match the EPA RSL table's analyte list. However, a number of synonyms can identify a single chemical, and variation in chemical naming may occur. In VURAM the CAS number is the primary analyte identification. In general, EPA RSL also uses CASRN to identify chemicals. However, RSL tables may use an EPA identification number for some analytes without a provided CAS. For chemicals included in VURAM that have no CAS or EPA ID number, or that have a duplicate CAS with distinct chemical properties, an unofficial value is assigned to the CAS Number in order to facilitate database function. These values are contrived by DEQ to be indicative of the compound or substance they are associated with, but are not reflective of the CAS or EPA assigned number. A table of these chemicals with EPA ID or DEQ assigned values for CAS is included in appendix A3.8.

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Appendices

A1.0 Equations and Parameters

Calculations for screening levels and/or quantitative risk calculations that differ from RSL User's Guide equations are noted in the associated section of this User Guide where they occur. Exposure default parameters for each receptor are provided at the beginning of each receptor section. Calculation constants, which apply to several equations across multiple receptor scenarios, and chemical-specific abbreviations are provided in this section. Values for chemical-specific parameters can be found in EPA RSL tables, VURAM Screening Setup page, and VURAM Quantitative Risk Assessment Setup page.

NOTE: Surface water screening does not include any physical or chemical parameters. It only includes chemical analytes.

NOTE: surface water screening does not screen any ecological endpoints.

IMPORTANT! Computation of quantitative risk assessment hazard/risk values requires solving the screening level equation algebraically for target hazard quotient (THQ)/target risk (TR) with the chemical concentration in place of screening level (SL) to obtain a HQ/risk value. An example of this algebraic process is provided in section A1.8.

Recreator and trespasser exposure scenarios are not included in the screening levels module. Sediment screening values are uniquely developed for VRP ONLY, and surface water screening values are unique to Virginia DEQ based on water quality criteria. However, VURAM quantitatively computes soil, sediment and surface water hazard/risk for the recreator and trespasser exposure scenarios in quantitative risk assessment using the recreator equations in section A1.4. Exposure default parameters for recreator and trespasser vary between scenarios.

IMPORTANT! VURAM is updated by DEQ to reflect the semiannual EPA RSL updates to toxicity values and other chemical parameters. Download and install the latest release of VURAM to calculate risk assessments with the most recent RSL data. Use the most recent update of the RSL table available at the time of data analysis and note the date of the RSL table in all risk assessments.

IMPORTANT! Site-specific exposure defaults, documented and approved by DEQ, may be substituted in the EPA hazard/risk calculation equations where appropriate. Such calculations must be manually added to the calculated hazard/risk for the media and total hazard/risk for the entire site.

Table A1.0-1 Chemical Specific Parameters

Symbol	Description	Units	Source
ABSd	Fraction of contaminant absorbed dermally from soil	(unitless)	EPA
B	Ratio of the permeability coefficient of a compound through the stratum coneum relative to its permeability coefficient across the viable epidermis (ve)	(unitless)	EPA
Csat	Soil Saturation Concentration	(mg/kg)	EPA

Symbol	Description	Units	Source
CSFo	Chronic Oral Slope Factor	(mg/kg/day)-1	EPA
Dia	Diffusivity in air	(cm2/s)	EPA
Diw	Diffusivity in water	(cm2/s)	EPA
FA	Fraction Absorbed Water	(unitless)	EPA
GIABS	Fraction of contaminant absorbed in gastrointestinal tract	(unitless)	EPA
H'	Dimensionless Henry's Law Constant	(unitless)	EPA
IUR	Chronic Inhalation Unit Risk	(µg/m)	EPA
Kd	Soil-water partition coefficient	(L/kg)	EPA
Koc	Soil organic carbon-water partition coefficient	(L/kg)	EPA
Kp	Dermal Permeability Constant	(cm/hour)	EPA
RBA	Relative Bioavailability	(unitless)	EPA
RfC	Chronic Inhalation Reference Concentration	(mg/m3)	EPA
RfCsc	Subchronic Inhalation Reference Concentration	(mg/m3)	EPA
RfDo	Chronic Oral Reference Dose	(mg/kg-day)	EPA
RfDosc	Subchronic Oral Reference Dose	(mg/kg-day)	EPA
S	Water Solubility Limit	(mg/L)	EPA
T*	Time to reach steady-state	(hrs)	EPA
TR-VFgt	Trench Volatilization Factor - groundwater greater than 15ft - Virginia DEQ	(L/m3)	DEQ
TR-VFlt	Trench Volatilization Factor - groundwater less than 15ft - Virginia DEQ	(L/m3)	DEQ
TR-VFsg	Trench Volatilization Factor - soil vapor source to ambient air - Virginia DEQ	(unitless)	DEQ
VFs	Volatilization Factor Soil - Los Angeles	(m3/kg)	EPA
VFsc	Subchronic Volitalization Factor - Virginia DEQ	(m3/kg)	DEQ
τ-event	Lag per Event	(hrs/event)	EPA

Table A1.0-2 Calculation Constants

Symbol	Description	Value	Units	Source
CAFi	Carcinogenic Adjustment Factor Inhalation - Tricholorethylene (TCE)	0.756	(unitless)	EPA
CAFo	Carcinogenic Adjustment Factor Oral - Tricholorethylene (TCE)	0.804	(unitless)	EPA
CF I	Conversion Factor I	0.000001	(kg/mg)	EPA
CF II	Conversion Factor II	1000	(µg/mg)	EPA
CF III	Conversion Factor III	0.001	(mg/µg)	EPA
K	Andelman Volatilization Factor	0.5	(L/m3)	EPA
LT	Life Time	70	(yrs)	EPA
MAFi	Mutagenic Adjustment Factor Inhalation - Tricholorethylene (TCE)	0.244	(unitless)	EPA
MAFo	Mutagenic Adjustment Factor Oral - Tricholorethylene (TCE)	0.202	(unitless)	EPA
PEFw	Particulate emission Factor - Minneapolis	1360000000	(m3/kg)	EPA

A1.1 Residential

Under the VRP, residential soil screening values include SSL DAF-20. For the development of SSL DAF-20 see appendix A1.7. For **VRP ONLY,** groundwater/tapwater screening levels are developed by choosing the MCL if it is available, OR the lower of Residential Tapwater TR = 1E-5 and Child HI = 0.1. Groundwater MCLs are not risk-based numbers; MCL values are provided in the RCRA screening report for reference only.

The groundwater vapor intrusion pathway (groundwater VI) is screened under the groundwater medium. Groundwater VI screening values are computed from contaminant concentrations in groundwater, **NOT** air. Refer to section A1.6 for groundwater VI equations. However, the quantitative risk assessment module does **NOT** calculate groundwater VI risk based on groundwater contaminant concentrations; air contaminant concentrations must be entered in µg/m^3. Refer to VISL Calculator User's Guide for more details.

The screening levels module does **NOT** include the food medium. Food calculations are not age dependent, however, noncancer hazard values for food are added to both the adult and child receptor totals in the quantitative risk assessment report. EPA RSL provides parameters and equations for fish consumption; for food groups other than fish DEQ ingestion rate values for the appropriate food group are used to compute hazard/risk.

Residential sediment and surface water exposure scenarios are calculated using recreator exposure defaults and equations. See section A1.4 for recreator values and equations.

Table A1.1-1 Residential Exposure Parameters

Symbol	Description	Value	Units	Source
AF0-02	Soil Adherence Factor - age segment 0-2	0.2	(mg/cm2)	EPA
AF02-06	Soil Adherence Factor - age segment 2-6	0.2	(mg/cm2)	EPA
AF06-16	Soil Adherence Factor - age segment 6-16	0.07	(mg/cm2)	EPA
AF16-26	Soil Adherence Factor - age segment 16-26	0.07	(mg/cm2)	EPA
AFres-a	Resident Soil Adherence Factor - adult	0.07	(mg/cm2)	EPA
AFres-c	Resident Soil Adherence Factor - child	0.2	(mg/cm2)	EPA
ATr	Resident Averaging Time	365	(days/yr)	EPA
ATres	Resident Averaging Time: 365 x LT	25550	(days)	EPA
ATres-a	Resident Averaging Time - adult: 365 x EDres	9490	(days)	EPA
ATres-c	Resident Averaging Time - child: 365 x EDres-c	2190	(days)	EPA
BW0-02	Body Weight - age segment 0-2	15	(kg)	EPA
BW02-06	Body Weight - age segment 2-6	15	(kg)	EPA
BW06-16	Body Weight - age segment 6-16	80	(kg)	EPA
BW16-26	Body Weight - age segment 16-26	80	(kg)	EPA
BWres-a	Resident Body Weight - adult	80	(kg)	EPA
BWres-c	Resident Body Weight - child	15	(kg)	EPA
DFSMres-adj	Resident Soil Mutagenic Dermal Contact Factor - age adjusted	428260	(mg/kg)	EPA
DFSres-adj	Resident Soil Dermal Contact Factor - age adjusted	103390	(mg/kg)	EPA
DFWMres-adj	Resident Groundwater Mutagenic Dermal Contact Factor - age adjusted	8191633	(cm2-event/kg)	EPA

Symbol	Description	Value	Units	Source
DFWres-adj	Resident Groundwater Dermal Contact Factor - age adjusted	2610650	(cm2-event/kg)	EPA
ED0-02	Exposure Duration - age segment 0-2	2	(yrs)	EPA
ED02-06	Exposure Duration - age segment 2-6	4	(yrs)	EPA
ED06-16	Exposure Duration -age segment 6-16	10	(yrs)	EPA
ED16-26	Exposure Duration -age segment 16-26	10	(yrs)	EPA
EDres	Resident Total Exposure Duration	26	(yrs)	EPA
EDres-a	Resident Exposure Duration - adult	20	(yrs)	EPA
EDres-c	Resident Exposure Duration - child	6	(yrs)	EPA
EFres	Resident Exposure Frequency	350	(days/yr)	EPA
EFres0-02	Resident Exposure Frequency - age segment 0-2	350	(days/yr)	EPA
EFres02-06	Resident Exposure Frequency - age segment 2-6	350	(days/yr)	EPA
EFres06-16	Resident Exposure Frequency - age segment 6-16	350	(days/yr)	EPA
EFres16-26	Resident Exposure Frequency - age segment 16-26	350	(days/yr)	EPA
EFres-a	Resident Exposure Frequency - adult	350	(days/yr)	EPA
EFres-c	Resident Exposure Frequency - child	350	(days/yr)	EPA
ETevent-res(0-02)	Resident Water Exposure Time - age segment 0-2	0.54	(hrs/event)	EPA
ETevent-res(02-06)	Resident Water Exposure Time - age segment 2-6	0.54	(hrs/event)	EPA
ETevent-res(06-16)	Resident Water Exposure Time - age segment 6-16	0.71	(hrs/event)	EPA
ETevent-res(16-26)	Resident Water Exposure Time - age segment 16-26	0.71	(hrs/event)	EPA

Symbol	Description	Value	Units	Source
ETevent-res-a	Resident Groundwater Exposure Time -adult	0.71	(hrs/event)	EPA
ETevent-res-adj	Resident Water Exposure Time -age adjusted	0.670769	(hrs/event)	EPA
ETevent-res-c	Resident Groundwater Exposure Time - child	0.54	(hrs/event)	EPA
ETevent-res-madj	Resident Water Exposure Time - mutagen age adjusted	0.670769	(hrs/event)	EPA
ETrai	Resident Air Inhalation Exposure Time	24	(hrs/day)	EPA
ETres	Resident Soil Exposure Time	24	(hrs/day)	EPA
ETres0-02	Resident Exposure Time - age segment 0-2	24	(hrs/day)	EPA
ETres02-06	Resident Exposure Time - age segment 2-6	24	(hrs/day)	EPA
ETres06-16	Resident Exposure Time - age segment 6-16	24	(hrs/day)	EPA
ETres16-26	Resident Exposure Time - age segment 16-26	24	(hrs/day)	EPA
ETres-a	Resident Exposure Time - adult	24	(hrs/day)	EPA
ETres-c	Resident Exposure Time - child	24	(hrs/day)	EPA
ETres-gwi	Resident Groundwater Inhalation Exposure Time	24	(hrs/day)	EPA
EVres-a	Resident Groundwater Events - adult	1	(events/day)	EPA
EVres-c	Resident Groundwater Events - child	1	(events/day)	EPA
IFSMres-adj	Resident Mutagenic Soil Ingestion Rate - age adjusted	166833.3	(mg/kg)	EPA
IFSres-adj	Resident Soil Ingestion Rate - age adjusted	36750	(mg/kg)	EPA
IFWMres-adj	Resident Mutagenic Drinking Groundwater Ingestion Rate - age adjusted	1019.9	(L/kg)	EPA
IFWres-adj	Resident Drinking Groundwater Ingestion Rate - age adjusted	327.95	(L/kg)	EPA

Symbol	Description	Value	Units	Source
INHMres-ai-adj	Resident Air Inhalation Exposure Duration Mutagen - age adjusted	604800	(hrs)	EPA
INHMres-gw-adj	Resident Groundwater Inhalation Exposure Duration Mutagen - age adjusted	25200	(days)	EPA
INHMres-s-adj	Resident Soil Inhalation Exposure Duration Mutagen - age adjusted	25200	(days)	EPA
IREres-a	Resident Food Eggs Ingestion Rate - Virginia DEQ	150000	(mg/day)	DEQ
IRFres-a	Resident Food Fish/Shellfish Ingestion Rate - Virginia DEQ	54000	(mg/day)	DEQ
IRFVres-a	Resident Food Fruit/Vegetables Ingestion Rate - Virginia DEQ	122000	(mg/day)	DEQ
IRMDres-a	Resident Food Meat/Dairy - Virginia DEQ	280000	(mg/day)	DEQ
IRS0-02	Soil/Sediment Ingestion Rate - age segment 0-2	200	(mg/day)	EPA
IRS02-06	Soil/Sediment Ingestion Rate - age segment 2-6	200	(mg/day)	EPA
IRS06-16	Soil/Sediment Ingestion Rate - age segment 6-16	100	(mg/day)	EPA
IRS16-26	Soil/Sediment Ingestion Rate - age segment 16-26	100	(mg/day)	EPA
IRSres-a	Resident Soil Ingestion Rate - adult	100	(mg/day)	EPA
IRSres-c	Resident Soil Ingestion Rate - child	200	(mg/day)	EPA
IRW0-02	Drinking Water Ingestion Rate - age segment 0-2	0.78	(L/day)	EPA
IRW02-06	Drinking Water Ingestion Rate - age segment 2-6	0.78	(L/day)	EPA
IRW06-16	Drinking Water Ingestion Rate - age segment 6-16	2.5	(L/day)	EPA
IRW16-26	Drinking Water Ingestion Rate - age segment 16-26	2.5	(L/day)	EPA

Symbol	Description	Value	Units	Source
IRWres-a	Resident Drinking Groundwater Ingestion Rate - adult	2.5	(L/day)	EPA
IRWres-c	Resident Drinking Groundwater Ingestion Rate - child	0.78	(L/day)	EPA
SAres-a	Resident Soil Surface Area - adult	6032	(cm2/day)	EPA
SAres-a	Resident Water Surface Area - adult	19652	(cm2)	EPA
SAres-c	Resident Water Surface Area - child	6365	(cm2)	EPA
SAres-c	Resident Soil Surface Area - child	2373	(cm2/day)	EPA
SAs0-02	Surface Area Soil/Sediment - age segment 0-2	2373	(cm2/day)	EPA
SAs02-06	Surface Area Soil/Sediment - age segment 2-6	2373	(cm2/day)	EPA
SAs06-16	Surface Area Soil/Sediment - age segment 6-16	6032	(cm2/day)	EPA
SAs16-26	Surface Area Soil/Sediment - age segment 16-26	6032	(cm2/day)	EPA
SAw0-02	Surface Area Water - age segment 0-2	6365	(cm2)	EPA
SAw02-06	Surface Area Water - age segment 2-6	6365	(cm2)	EPA
SAw06-16	Surface Area Water - age segment 6- 16	19652	(cm2)	EPA
SAw16-26	Surface Area Water - age segment 16- 26	19652	(cm2)	EPA

A1.1.1 Soil

Noncarcinogenic-child

Ingestion

$$SL_{res\text{-}soil\text{-}nc\text{-}ing\text{-}c}\left(mg/kg\right) = \frac{THQ \times AT_{res\text{-}c}\left(\frac{365\ days}{year} \times ED_{res\text{-}c}\left(6\ years\right)\right) \times BW_{res\text{-}c}\left(15\ kg\right)}{EF_{res\text{-}c}\left(\frac{350\ days}{year}\right) \times ED_{res\text{-}c}\left(6\ years\right) \times \frac{RBA}{RfD_o\left(\frac{mg}{kg\text{-}day}\right)} \times IRS_{res\text{-}c}\left(\frac{200\ mg}{day}\right) \times \frac{10^{-6}\ kg}{1\ mg}}$$

Dermal

$$SL_{res\text{-}soil\text{-}nc\text{-}der\text{-}c}\,(mg/kg) = \frac{THQ \times AT_{res\text{-}c}\left(\frac{365\ days}{year} \times ED_{res\text{-}c}\,(6\ years)\right) \times BW_{res\text{-}c}\,(15\ kg)}{EF_{res\text{-}c}\left(\frac{350\ days}{year}\right) \times ED_{res\text{-}c}\,(6\ years) \times \frac{1}{\left(RfD_o\left(\frac{mg}{kg\text{-}day}\right) \times GIABS\right)} \times SA_{res\text{-}c}\left(\frac{2373\ cm^2}{day}\right) \times AF_{res\text{-}c}\left(\frac{0.2\ mg}{cm^2}\right) \times ABS_d \times \frac{10^{-6} kg}{1mg}}$$

Inhalation

$$SL_{res\text{-}soil\text{-}nc\text{-}inh\text{-}c}\,(mg/kg) = \frac{THQ \times AT_{res\text{-}c}\left(\frac{365\ days}{year} \times ED_{res\text{-}c}\,(6\ years)\right)}{EF_{res\text{-}c}\left(\frac{350\ days}{year}\right) \times ED_{res\text{-}c}\,(6\ years) \times ET_{res\text{-}c}\left(\frac{24\ hours}{day}\right) \times \left(\frac{1\ day}{24\ hours}\right) \times \frac{1}{RfC\left(\frac{mg}{m^3}\right)} \times \left(\frac{1}{VF_s\left(\frac{m^3}{kg}\right)} + \frac{1}{PEF_w\left(\frac{m^3}{kg}\right)}\right)}$$

Total

$$SL_{res\text{-}soil\text{-}nc\text{-}tot\text{-}c}\,(mg/kg) = \frac{1}{\frac{1}{SL_{res\text{-}soil\text{-}nc\text{-}ing\text{-}c}} + \frac{1}{SL_{res\text{-}soil\text{-}nc\text{-}der\text{-}c}} + \frac{1}{SL_{res\text{-}soil\text{-}nc\text{-}inh\text{-}c}}}$$

Noncarcinogenic-adult

Ingestion

$$SL_{res\text{-}soil\text{-}nc\text{-}ing\text{-}a}\,(mg/kg) = \frac{THQ \times AT_{res\text{-}a}\left(\frac{365\ days}{year} \times ED_{res}\,(26\ years)\right) \times BW_{res\text{-}a}\,(80\ kg)}{EF_{res\text{-}a}\left(\frac{350\ days}{year}\right) \times ED_{res}\,(26\ years) \times \frac{RBA}{RfD_o\left(\frac{mg}{kg\text{-}day}\right)} \times IRS_{res\text{-}a}\left(\frac{100\ mg}{day}\right) \times \frac{10^{-6} kg}{1mg}}$$

Dermal

$$SL_{res\text{-}soil\text{-}nc\text{-}der\text{-}a}\,(mg/kg) = \frac{THQ \times AT_{res\text{-}a}\left(\frac{365\ days}{year} \times ED_{res}\,(26\ years)\right) \times BW_{res\text{-}a}\,(80\ kg)}{EF_{res\text{-}a}\left(\frac{350\ days}{year}\right) \times ED_{res}\,(26\ years) \times \frac{1}{\left(RfD_o\left(\frac{mg}{kg\text{-}day}\right) \times GIABS\right)} \times SA_{res\text{-}a}\left(\frac{6032\ cm^2}{day}\right) \times AF_{res\text{-}a}\left(\frac{0.07\ mg}{cm^2}\right) \times ABS_d \times \frac{10^{-6} kg}{1mg}}$$

Inhalation

$$SL_{res\text{-}soil\text{-}nc\text{-}inh\text{-}a}\,(mg/kg) = \frac{THQ \times AT_{res\text{-}a}\left(\frac{365\ days}{year} \times ED_{res}\,(26\ years)\right)}{EF_{res\text{-}a}\left(\frac{350\ days}{year}\right) \times ED_{res}\,(26\ years) \times ET_{res\text{-}a}\left(\frac{24\ hours}{day}\right) \times \left(\frac{1\ day}{24\ hours}\right) \times \frac{1}{RfC\left(\frac{mg}{m^3}\right)} \times \left(\frac{1}{VF_s\left(\frac{m^3}{kg}\right)} + \frac{1}{PEF_w\left(\frac{m^3}{kg}\right)}\right)}$$

<u>**Carcinogenic**</u>

Ingestion

$$SL_{res\text{-}soil\text{-}ca\text{-}ing}\,(mg/kg) = \frac{TR \times AT_{res}\left(\frac{365\ days}{year} \times LT\,(70\ years)\right)}{CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1} \times RBA \times IFS_{res\text{-}adj}\left(\frac{36{,}750\ mg}{kg}\right) \times \left(\frac{10^{-6}kg}{mg}\right)}$$

where:

$$IFS_{res\text{-}adj}\left(\frac{36{,}750\ mg}{kg}\right) = \left(\frac{EF_{res\text{-}c}\left(\frac{350\ days}{year}\right) \times ED_{res\text{-}c}\,(6\ years) \times IRS_{res\text{-}c}\left(\frac{200\ mg}{day}\right)}{BW_{res\text{-}c}\,(15\ kg)} + \frac{EF_{res\text{-}a}\left(\frac{350\ days}{year}\right) \times \left(ED_{res}\,(26\ years) - ED_{res\text{-}c}\,(6\ years)\right) \times IRS_{res\text{-}a}\left(\frac{100\ mg}{day}\right)}{BW_{res\text{-}a}\,(80\ kg)}\right)$$

Dermal

$$SL_{res\text{-}soil\text{-}ca\text{-}der}\,(mg/kg) = \frac{TR \times AT_{res}\left(\frac{365\ days}{year} \times LT\,(70\ years)\right)}{\left(\frac{CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1}}{GIABS}\right) \times DFS_{res\text{-}adj}\left(\frac{103{,}390\ mg}{kg}\right) \times ABS_d \times \left(\frac{10^{-6}kg}{mg}\right)}$$

where:

$$DFS_{res\text{-}adj}\left(\frac{103{,}390\ mg}{kg}\right) = \left(\frac{EF_{res\text{-}c}\left(\frac{350\ days}{year}\right) \times ED_{res\text{-}c}\,(6\ years) \times SA_{res\text{-}c}\left(\frac{2373\ cm^2}{day}\right) \times AF_{res\text{-}c}\left(\frac{0.2\ mg}{cm^2}\right)}{BW_{res\text{-}c}\,(15\ kg)} + \frac{EF_{res\text{-}a}\left(\frac{350\ days}{year}\right) \times \left(ED_{res}\,(26\ years) - ED_{res\text{-}c}\,(6\ years)\right) \times SA_{res\text{-}a}\left(\frac{6032\ cm^2}{day}\right) \times AF_{res\text{-}a}\left(\frac{0.07\ mg}{cm^2}\right)}{BW_{res\text{-}a}\,(80\ kg)}\right)$$

Inhalation

$$SL_{res\text{-}soil\text{-}ca\text{-}inh}\,(mg/kg) = \frac{TR \times AT_{res}\left(\frac{365\ days}{year} \times LT\,(70\ years)\right)}{IUR\left(\mu g/m^3\right)^{-1} \times \left(\frac{1000\ \mu g}{mg}\right) \times EF_{res}\left(\frac{350\ days}{year}\right) \times \left(\frac{1}{VF_s\left(\frac{m^3}{kg}\right)} + \frac{1}{PEF_w\left(\frac{m^3}{kg}\right)}\right) \times ED_{res}\,(26\ years) \times ET_{res}\left(\frac{24\ hours}{day}\right) \times \left(\frac{1\ day}{24\ hours}\right)}$$

Total

$$SL_{res\text{-}soil\text{-}ca\text{-}tot}\,(mg/kg) = \frac{1}{\frac{1}{SL_{res\text{-}soil\text{-}ca\text{-}ing}} + \frac{1}{SL_{res\text{-}soil\text{-}ca\text{-}der}} + \frac{1}{SL_{res\text{-}soil\text{-}ca\text{-}inh}}}$$

Mutagenic

Ingestion

$$SL_{res\text{-}soil\text{-}mu\text{-}ing}\,(mg/kg) = \frac{TR \times AT_{res}\left(\frac{365\ days}{year} \times LT\,(70\ years)\right)}{CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1} \times RBA \times IFSM_{res\text{-}adj}\left(\frac{166{,}833\ mg}{kg}\right) \times \left(\frac{10^{-6} kg}{mg}\right)}$$

where:

$$IFSM_{res\text{-}adj}\left(\frac{166{,}833\ mg}{kg}\right) = \left(\begin{array}{l} \frac{EF_{0\text{-}2}\left(\frac{350\ days}{year}\right) \times ED_{0\text{-}2}\,(2\ years) \times IRS_{0\text{-}2}\left(\frac{200\ mg}{day}\right) \times 10}{BW_{0\text{-}2}\,(15\ kg)} + \\ \frac{EF_{2\text{-}6}\left(\frac{350\ days}{year}\right) \times ED_{2\text{-}6}\,(4\ years) \times IRS_{2\text{-}6}\left(\frac{200\ mg}{day}\right) \times 3}{BW_{2\text{-}6}\,(15\ kg)} + \\ \frac{EF_{6\text{-}16}\left(\frac{350\ days}{year}\right) \times ED_{6\text{-}16}\,(10\ years) \times IRS_{6\text{-}16}\left(\frac{100\ mg}{day}\right) \times 3}{BW_{6\text{-}16}\,(80\ kg)} + \\ \frac{EF_{16\text{-}26}\left(\frac{350\ days}{year}\right) \times ED_{16\text{-}26}\,(10\ years) \times IRS_{16\text{-}26}\left(\frac{100\ mg}{day}\right) \times 1}{BW_{16\text{-}26}\,(80\ kg)} \end{array}\right)$$

Dermal

$$SL_{res\text{-}soil\text{-}mu\text{-}der}\,(mg/kg) = \frac{TR \times AT_{res}\left(\frac{365\ days}{year} \times LT\,(70\ years)\right)}{\left(\frac{CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1}}{GIABS}\right) \times DFSM_{res\text{-}adj}\left(\frac{428{,}260\ mg}{kg}\right) \times ABS_d \times \left(\frac{10^{-6} kg}{mg}\right)}$$

where:

$$DFSM_{res\text{-}adj}\left(\frac{428{,}260\ mg}{kg}\right) = \left(\begin{array}{l} \frac{EF_{0\text{-}2}\left(\frac{350\ days}{year}\right) \times ED_{0\text{-}2}\,(2\ years) \times AF_{0\text{-}2}\left(\frac{0.2\ mg}{cm^2}\right) \times SA_{0\text{-}2}\left(\frac{2373\ cm^2}{day}\right) \times 10}{BW_{0\text{-}2}\,(15\ kg)} + \\ \frac{EF_{2\text{-}6}\left(\frac{350\ days}{year}\right) \times ED_{2\text{-}6}\,(4\ years) \times AF_{2\text{-}6}\left(\frac{0.2\ mg}{cm^2}\right) \times SA_{2\text{-}6}\left(\frac{2373\ cm^2}{day}\right) \times 3}{BW_{2\text{-}6}\,(15\ kg)} + \\ \frac{EF_{6\text{-}16}\left(\frac{350\ days}{year}\right) \times ED_{6\text{-}16}\,(10\ years) \times AF_{6\text{-}16}\left(\frac{0.07\ mg}{cm^2}\right) \times SA_{6\text{-}16}\left(\frac{6032\ cm^2}{day}\right) \times 3}{BW_{6\text{-}16}\,(80\ kg)} + \\ \frac{EF_{16\text{-}26}\left(\frac{350\ days}{year}\right) \times ED_{16\text{-}26}\,(10\ years) \times AF_{16\text{-}26}\left(\frac{0.07\ mg}{cm^2}\right) \times SA_{16\text{-}26}\left(\frac{6032\ cm^2}{day}\right) \times 1}{BW_{16\text{-}26}\,(80\ kg)} \end{array}\right)$$

Inhalation

$$SL_{res\text{-}soil\text{-}mu\text{-}inh}(mg/kg)=\frac{TR\times AT_{res}\left(\frac{365\ days}{year}\times LT\,(70\ years)\right)}{IUR\left(\mu g/m^3\right)^{-1}\times\left(\frac{1}{VF_s\left(\frac{m^3}{kg}\right)}+\frac{1}{PEF_w\left(\frac{m^3}{kg}\right)}\right)\times\left(\frac{1000\ \mu g}{mg}\right)\times\left(\begin{array}{l}\left(ET_{0\text{-}2}\left(\frac{24\ hours}{day}\right)\times\left(\frac{1\ day}{24\ hours}\right)\times EF_{0\text{-}2}\left(\frac{350\ days}{year}\right)\times ED_{0\text{-}2}\,(2\ years)\times 10\right)+\\\left(ET_{2\text{-}6}\left(\frac{24\ hours}{day}\right)\times\left(\frac{1\ day}{24\ hours}\right)\times EF_{2\text{-}6}\left(\frac{350\ days}{year}\right)\times ED_{2\text{-}6}\,(4\ years)\times 3\right)+\\\left(ET_{6\text{-}16}\left(\frac{24\ hours}{day}\right)\times\left(\frac{1\ day}{24\ hours}\right)\times EF_{6\text{-}16}\left(\frac{350\ days}{year}\right)\times ED_{6\text{-}16}\,(10\ years)\times 3\right)+\\\left(ET_{16\text{-}26}\left(\frac{24\ hours}{day}\right)\times\left(\frac{1\ day}{24\ hours}\right)\times EF_{16\text{-}26}\left(\frac{350\ days}{year}\right)\times ED_{16\text{-}26}\,(10\ years)\times 1\right)\end{array}\right)}$$

Total

$$SL_{res\text{-}soil\text{-}mu\text{-}tot}(mg/kg)=\frac{1}{\frac{1}{SL_{res\text{-}soil\text{-}mu\text{-}ing}}+\frac{1}{SL_{res\text{-}soil\text{-}mu\text{-}der}}+\frac{1}{SL_{res\text{-}soil\text{-}mu\text{-}inh}}}$$

<u>Vinyl Chloride</u>

Ingestion

$$SL_{res\text{-}soil\text{-}ca\text{-}vc\text{-}ing}(mg/kg)=\frac{TR}{\left(\frac{CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1}\times RBA\times IFS_{res\text{-}adj}\left(\frac{36{,}750\ mg}{kg}\right)\times\frac{10^{-6}kg}{1\ mg}}{AT_{res}\left(\frac{365\ days}{year}\times LT\,(70\ years)\right)}\right)+\left(\frac{CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1}\times RBA\times IRS_{res\text{-}c}\left(\frac{200\ mg}{day}\right)\times\frac{10^{-6}kg}{1\ mg}}{BW_{res\text{-}c}\,(15\ kg)}\right)}$$

where:

$$IFS_{res\text{-}adj}\left(\frac{36{,}750\ mg}{kg}\right)=\left(\begin{array}{l}\frac{EF_{res\text{-}c}\left(\frac{350\ days}{year}\right)\times ED_{res\text{-}c}\,(6\ years)\times IRS_{res\text{-}c}\left(\frac{200\ mg}{day}\right)}{BW_{res\text{-}c}\,(15\ kg)}+\\\frac{EF_{res\text{-}a}\left(\frac{350\ days}{year}\right)\times\left(ED_{res}\,(26\ years)-ED_{res\text{-}c}\,(6\ years)\right)\times IRS_{res\text{-}a}\left(\frac{100\ mg}{day}\right)}{BW_{res\text{-}a}\,(80\ kg)}\end{array}\right)$$

Dermal

$$SL_{res\text{-}soil\text{-}ca\text{-}vc\text{-}der}\left(mg/kg\right)=\frac{TR}{\left(\frac{\frac{CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1}}{GIABS}\times DFS_{res\text{-}adj}\left(\frac{103{,}390\ mg}{kg}\right)\times ABS_d\times\frac{10^{-6}kg}{1\ mg}}{AT_{res}\left(\frac{365\ days}{year}\times LT\left(70\ years\right)\right)}\right)+\left(\frac{\frac{CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1}}{GIABS}\times SA_{res\text{-}c}\left(\frac{2373\ cm^2}{day}\right)\times AF_{res\text{-}c}\left(\frac{0.2\ mg}{cm^2}\right)\times ABS\times\frac{10^{-6}kg}{1\ mg}}{BW_{res\text{-}c}\left(15\ kg\right)}\right)}$$

where:

$$DFS_{res\text{-}adj}\left(\frac{103{,}390\ mg}{kg}\right)=\left(\frac{EF_{res\text{-}c}\left(\frac{350\ days}{year}\right)\times ED_{res\text{-}c}\left(6\ years\right)\times SA_{res\text{-}c}\left(\frac{2373\ cm^2}{day}\right)\times AF_{res\text{-}c}\left(\frac{0.2\ mg}{cm^2}\right)}{BW_{res\text{-}c}\left(15\ kg\right)}+\frac{EF_{res\text{-}a}\left(\frac{350\ days}{year}\right)\times\left(ED_{res}\left(26\ years\right)-ED_{res\text{-}c}\left(6\ years\right)\right)\times SA_{res\text{-}a}\left(\frac{6032\ cm^2}{day}\right)\times AF_{res\text{-}a}\left(\frac{0.07\ mg}{cm^2}\right)}{BW_{res\text{-}a}\left(80\ kg\right)}\right)$$

Inhalation

$$SL_{res\text{-}soil\text{-}ca\text{-}vc\text{-}inh}\left(mg/kg\right)=\frac{TR}{\left(\frac{IUR\left(\mu g/m^3\right)^{-1}\times EF_{res}\left(\frac{350\ days}{year}\right)\times ED_{res}\left(26\ years\right)\times ET_{res}\left(\frac{24\ hours}{day}\right)\times\left(\frac{1\ day}{24\ hours}\right)\times\left(\frac{1000\ \mu g}{mg}\right)}{AT_{res}\left(\frac{365\ days}{year}\times LT\left(70\ years\right)\right)\times VF_s\left(\frac{m^3}{kg}\right)}\right)+\left(\frac{IUR\left(\mu g/m^3\right)^{-1}}{VF_s\left(\frac{m^3}{kg}\right)}\times\left(\frac{1000\ \mu g}{mg}\right)\right)}$$

Total

$$SL_{res\text{-}soil\text{-}ca\text{-}vc\text{-}tot}\left(mg/kg\right)=\frac{1}{\frac{1}{SL_{res\text{-}soil\text{-}ca\text{-}vc\text{-}ing}}+\frac{1}{SL_{res\text{-}soil\text{-}ca\text{-}vc\text{-}der}}+\frac{1}{SL_{res\text{-}soil\text{-}ca\text{-}vc\text{-}inh}}}$$

Trichloroethylene

Ingestion

$$SL_{res\text{-}soil\text{-}tce\text{-}ing}\left(mg/kg\right) = \frac{TR \times AT_{res}\left(\frac{365\ days}{year} \times LT\ (70\ years)\right)}{CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1} \times RBA \times \left(\frac{10^{-6} kg}{mg}\right) \times \left(\left(CAF_o\ (0.804) \times IFS_{res\text{-}adj}\left(\frac{37{,}650\ mg}{kg}\right)\right) + \left(MAF_o\ (0.202) \times IFSM_{res\text{-}adj}\left(\frac{166{,}833\ mg}{kg}\right)\right)\right)}$$

where:

$$IFS_{res\text{-}adj}\left(\frac{36{,}750\ mg}{kg}\right) = \left(\begin{array}{l}\frac{ED_{res\text{-}c}\ (6\ years) \times EF_{res\text{-}c}\left(\frac{350\ days}{year}\right) \times IRS_{res\text{-}c}\left(\frac{200\ mg}{day}\right)}{BW_{res\text{-}c}\ (15\ kg)} + \\ \frac{\left(ED_{res}\ (26\ years) - ED_{res\text{-}c}\ (6\ years)\right) \times EF_{res\text{-}a}\left(\frac{350\ days}{year}\right) \times IRS_{res\text{-}a}\left(\frac{100\ mg}{day}\right)}{BW_{res\text{-}a}\ (80\ kg)}\end{array}\right)$$

where:

$$IFSM_{res\text{-}adj}\left(\frac{166{,}833\ mg}{kg}\right) = \left(\begin{array}{l}\frac{ED_{0\text{-}2}\ (2\ years) \times EF_{0\text{-}2}\left(\frac{350\ days}{year}\right) \times IRS_{0\text{-}2}\left(\frac{200\ mg}{day}\right) \times 10}{BW_{0\text{-}2}\ (15\ kg)} + \\ \frac{ED_{2\text{-}6}\ (4\ years) \times EF_{2\text{-}6}\left(\frac{350\ days}{year}\right) \times IRS_{2\text{-}6}\left(\frac{200\ mg}{day}\right) \times 3}{BW_{2\text{-}6}\ (15\ kg)} + \\ \frac{ED_{6\text{-}16}\ (10\ years) \times EF_{6\text{-}16}\left(\frac{350\ days}{year}\right) \times IRS_{6\text{-}16}\left(\frac{100\ mg}{day}\right) \times 3}{BW_{6\text{-}16}\ (80\ kg)} + \\ \frac{ED_{16\text{-}26}\ (10\ years) \times EF_{16\text{-}26}\left(\frac{350\ days}{year}\right) \times IRS_{16\text{-}26}\left(\frac{100\ mg}{day}\right) \times 1}{BW_{16\text{-}26}\ (80\ kg)}\end{array}\right)$$

Dermal

$$SL_{res\text{-}soil\text{-}tce\text{-}der}(mg/kg)=\frac{TR\times AT_{res}\left(\frac{365\ days}{year}\times LT\,(70\ years)\right)}{\left(\frac{CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1}}{GIABS}\right)\times\left(\frac{10^{-6}kg}{mg}\right)\times\left(\left(CAF_o\,(0.804)\times DFS_{res\text{-}adj}\left(\frac{103{,}390\ mg}{kg}\right)\times ABS_d\right)+\left(MAF_o\,(0.202)\times DFSM_{res\text{-}adj}\left(\frac{428{,}260\ mg}{kg}\right)\times ABS_d\right)\right)}$$

where:

$$DFS_{res\text{-}adj}\left(\frac{103{,}390\ mg}{kg}\right)=\left(\frac{ED_{res\text{-}c}\,(6\ years)\times EF_{res\text{-}c}\left(\frac{350\ days}{year}\right)\times SA_{res\text{-}c}\left(\frac{2373\ cm^2}{day}\right)\times AF_{res\text{-}c}\left(\frac{0.2\ mg}{cm^2}\right)}{BW_{res\text{-}c}\,(15\ kg)}+\frac{\left(ED_{res}\,(26\ years)-ED_{res\text{-}c}\,(6\ years)\right)\times EF_{res\text{-}a}\left(\frac{350\ days}{year}\right)\times SA_{res\text{-}a}\left(\frac{6032\ cm^2}{day}\right)\times AF_{res\text{-}a}\left(\frac{0.07\ mg}{cm^2}\right)}{BW_{res\text{-}a}\,(80\ kg)}\right)$$

where:

$$DFSM_{res\text{-}adj}\left(\frac{428{,}260\ mg}{kg}\right)=\left(\begin{array}{l}\frac{ED_{0\text{-}2}\,(2\ years)\times EF_{0\text{-}2}\left(\frac{350\ days}{year}\right)\times AF_{0\text{-}2}\left(\frac{0.2\ mg}{cm^2}\right)\times SA_{0\text{-}2}\left(\frac{2373\ cm^2}{day}\right)\times 10}{BW_{0\text{-}2}\,(15\ kg)}+\\ \frac{ED_{2\text{-}6}\,(4\ years)\times EF_{2\text{-}6}\left(\frac{350\ days}{year}\right)\times AF_{2\text{-}6}\left(\frac{0.2\ mg}{cm^2}\right)\times SA_{2\text{-}6}\left(\frac{2373\ cm^2}{day}\right)\times 3}{BW_{2\text{-}6}\,(15\ kg)}+\\ \frac{ED_{6\text{-}16}\,(10\ years)\times EF_{6\text{-}16}\left(\frac{350\ days}{year}\right)\times AF_{6\text{-}16}\left(\frac{0.07\ mg}{cm^2}\right)\times SA_{6\text{-}16}\left(\frac{6032\ cm^2}{day}\right)\times 3}{BW_{6\text{-}16}\,(80\ kg)}+\\ \frac{ED_{16\text{-}26}\,(10\ years)\times EF_{16\text{-}26}\left(\frac{350\ days}{year}\right)\times AF_{16\text{-}26}\left(\frac{0.07\ mg}{cm^2}\right)\times SA_{16\text{-}26}\left(\frac{6032\ cm^2}{day}\right)\times 1}{BW_{16\text{-}26}\,(80\ kg)}\end{array}\right)$$

Inhalation

$$SL_{res\text{-}soil\text{-}tce\text{-}inh}(mg/kg)=\frac{TR\times AT_{res}\left(\frac{365\ days}{year}\times LT\,(70\ years)\right)}{\begin{array}{l}IUR\left(\mu g/m^3\right)^{-1}\times\left(\frac{1}{VF_s\left(\frac{m^3}{kg}\right)}+\frac{1}{PEF_w\left(\frac{m^3}{kg}\right)}\right)\times\left(\frac{1000\ \mu g}{mg}\right)\times\left(\frac{1\ day}{24\ hours}\right)\times\\ \left(\left(\begin{array}{l}CAF_i\,(0.756)\times EF_{res}\left(\frac{350\ days}{year}\right)\times\\ ED_{res}\,(26\ years)\times ET_{res}\left(\frac{24\ hours}{day}\right)\end{array}\right)+\left(\begin{array}{l}\left(ED_{0\text{-}2}\,(2\ years)\times EF_{0\text{-}2}\left(\frac{350\ days}{year}\right)\times ET_{0\text{-}2}\left(\frac{24\ hours}{day}\right)\times MAF_i\,(0.244)\times 10\right)+\\ \left(ED_{2\text{-}6}\,(4\ years)\times EF_{2\text{-}6}\left(\frac{350\ days}{year}\right)\times ET_{2\text{-}6}\left(\frac{24\ hours}{day}\right)\times MAF_i\,(0.244)\times 3\right)+\\ \left(ED_{6\text{-}16}\,(10\ years)\times EF_{6\text{-}16}\left(\frac{350\ days}{year}\right)\times ET_{6\text{-}16}\left(\frac{24\ hours}{day}\right)\times MAF_i\,(0.244)\times 3\right)+\\ \left(ED_{16\text{-}26}\,(10\ years)\times EF_{16\text{-}26}\left(\frac{350\ days}{year}\right)\times ET_{16\text{-}26}\left(\frac{24\ hours}{day}\right)\times MAF_i\,(0.244)\times 1\right)\end{array}\right)\right)\end{array}}$$

Total

$$SL_{res\text{-}soil\text{-}tce\text{-}tot}(mg/kg)=\frac{1}{\frac{1}{SL_{res\text{-}soil\text{-}tce\text{-}ing}}+\frac{1}{SL_{res\text{-}soil\text{-}tce\text{-}der}}+\frac{1}{SL_{res\text{-}soil\text{-}tce\text{-}inh}}}$$

Supporting Equations

Child

$$ED_{res\text{-}c}\,(6\text{ years}) = ED_{0\text{-}2}\,(2\text{ years}) + ED_{2\text{-}6}\,(4\text{ years})$$

$$BW_{res\text{-}c}\,(15\text{ kg}) = \frac{BW_{0\text{-}2}\,(15\text{ kg}) \times ED_{0\text{-}2}\,(2\text{ years}) + BW_{2\text{-}6}\,(15\text{ kg}) \times ED_{2\text{-}6}\,(4\text{ years})}{ED_{0\text{-}2}\,(2\text{ years}) + ED_{2\text{-}6}\,(4\text{ years})}$$

$$EF_{res\text{-}c}\left(\frac{350\text{ days}}{\text{year}}\right) = \frac{EF_{0\text{-}2}\left(\frac{350\text{ days}}{\text{year}}\right) \times ED_{0\text{-}2}\,(2\text{ years}) + EF_{2\text{-}6}\left(\frac{350\text{ days}}{\text{year}}\right) \times ED_{2\text{-}6}\,(4\text{ years})}{ED_{0\text{-}2}\,(2\text{ years}) + ED_{2\text{-}6}\,(4\text{ years})}$$

$$ET_{res\text{-}c}\left(\frac{24\text{ hours}}{\text{day}}\right) = \frac{ET_{0\text{-}2}\left(\frac{24\text{ hours}}{\text{day}}\right) \times ED_{0\text{-}2}\,(2\text{ years}) + ET_{2\text{-}6}\left(\frac{24\text{ hours}}{\text{day}}\right) \times ED_{2\text{-}6}\,(4\text{ years})}{ED_{0\text{-}2}\,(2\text{ years}) + ED_{2\text{-}6}\,(4\text{ years})}$$

$$AF_{res\text{-}c}\left(\frac{0.2\text{ mg}}{\text{cm}^2}\right) = \frac{AF_{0\text{-}2}\left(\frac{0.2\text{ mg}}{\text{cm}^2}\right) \times ED_{0\text{-}2}\,(2\text{ years}) + AF_{2\text{-}6}\left(\frac{0.2\text{ mg}}{\text{cm}^2}\right) \times ED_{2\text{-}6}\,(4\text{ years})}{ED_{0\text{-}2}\,(2\text{ years}) + ED_{2\text{-}6}\,(4\text{ years})}$$

$$SA_{res\text{-}c}\left(\frac{2373\text{ cm}^2}{\text{day}}\right) = \frac{SA_{0\text{-}2}\left(\frac{2373\text{ cm}^2}{\text{day}}\right) \times ED_{0\text{-}2}\,(2\text{ years}) + SA_{2\text{-}6}\left(\frac{2373\text{ cm}^2}{\text{day}}\right) \times ED_{2\text{-}6}\,(4\text{ years})}{ED_{0\text{-}2}\,(2\text{ years}) + ED_{2\text{-}6}\,(4\text{ years})}$$

$$IRS_{res\text{-}c}\left(\frac{200\text{ mg}}{\text{day}}\right) = \frac{IRS_{0\text{-}2}\left(\frac{200\text{ mg}}{\text{day}}\right) \times ED_{0\text{-}2}\,(2\text{ years}) + IRS_{2\text{-}6}\left(\frac{200\text{ mg}}{\text{day}}\right) \times ED_{2\text{-}6}\,(4\text{ years})}{ED_{0\text{-}2}\,(2\text{ years}) + ED_{2\text{-}6}\,(4\text{ years})}$$

Adult

$$ED_{res\text{-}a}\left(20\ \text{years}\right) = ED_{6\text{-}16}\left(10\ \text{years}\right) + ED_{16\text{-}26}\left(10\ \text{years}\right)$$

$$BW_{res\text{-}a}\left(80\ \text{kg}\right) = \frac{BW_{6\text{-}16}\left(80\ \text{kg}\right) \times ED_{6\text{-}16}\left(10\ \text{years}\right) + BW_{16\text{-}26}\left(80\ \text{kg}\right) \times ED_{16\text{-}26}\left(10\ \text{years}\right)}{ED_{6\text{-}16}\left(10\ \text{years}\right) + ED_{16\text{-}26}\left(10\ \text{years}\right)}$$

$$EF_{res\text{-}a}\left(\frac{350\ \text{days}}{\text{year}}\right) = \frac{EF_{6\text{-}16}\left(\frac{350\ \text{days}}{\text{year}}\right) \times ED_{6\text{-}16}\left(10\ \text{years}\right) + EF_{16\text{-}26}\left(\frac{350\ \text{days}}{\text{year}}\right) \times ED_{16\text{-}26}\left(10\ \text{years}\right)}{ED_{6\text{-}16}\left(10\ \text{years}\right) + ED_{16\text{-}26}\left(10\ \text{years}\right)}$$

$$ET_{res\text{-}a}\left(\frac{24\ \text{hours}}{\text{day}}\right) = \frac{ET_{6\text{-}16}\left(\frac{24\ \text{hours}}{\text{day}}\right) \times ED_{6\text{-}16}\left(2\ \text{years}\right) + ET_{16\text{-}26}\left(\frac{24\ \text{hours}}{\text{day}}\right) \times ED_{16\text{-}26}\left(4\ \text{years}\right)}{ED_{6\text{-}16}\left(2\ \text{years}\right) + ED_{16\text{-}26}\left(4\ \text{years}\right)}$$

$$AF_{res\text{-}a}\left(\frac{0.07\ \text{mg}}{\text{cm}^2}\right) = \frac{AF_{6\text{-}16}\left(\frac{0.07\ \text{mg}}{\text{cm}^2}\right) \times ED_{6\text{-}16}\left(10\ \text{years}\right) + AF_{16\text{-}26}\left(\frac{0.07\ \text{mg}}{\text{cm}^2}\right) \times ED_{16\text{-}26}\left(10\ \text{years}\right)}{ED_{6\text{-}16}\left(10\ \text{years}\right) + ED_{16\text{-}26}\left(10\ \text{years}\right)}$$

$$SA_{res\text{-}a}\left(\frac{6032\ \text{cm}^2}{\text{day}}\right) = \frac{SA_{6\text{-}16}\left(\frac{6032\ \text{cm}^2}{\text{day}}\right) \times ED_{6\text{-}16}\left(10\ \text{years}\right) + SA_{16\text{-}26}\left(\frac{6032\ \text{cm}^2}{\text{day}}\right) \times ED_{16\text{-}26}\left(10\ \text{years}\right)}{ED_{6\text{-}16}\left(10\ \text{years}\right) + ED_{16\text{-}26}\left(10\ \text{years}\right)}$$

$$IRS_{res\text{-}a}\left(\frac{100\ \text{mg}}{\text{day}}\right) = \frac{IRS_{6\text{-}16}\left(\frac{100\ \text{mg}}{\text{day}}\right) \times ED_{6\text{-}16}\left(10\ \text{years}\right) + IRS_{16\text{-}26}\left(\frac{100\ \text{mg}}{\text{day}}\right) \times ED_{16\text{-}26}\left(10\ \text{years}\right)}{ED_{6\text{-}16}\left(10\ \text{years}\right) + ED_{16\text{-}26}\left(10\ \text{years}\right)}$$

Age-adjusted

$$ED_{res}\left(26\ \text{years}\right) = ED_{0\text{-}2}\left(2\ \text{years}\right) + ED_{2\text{-}6}\left(4\ \text{years}\right) + ED_{6\text{-}16}\left(10\ \text{years}\right) + ED_{16\text{-}26}\left(10\ \text{years}\right)$$

$$EF_{res}\left(\frac{350\ \text{days}}{\text{year}}\right) = \frac{\begin{array}{c} EF_{0\text{-}2}\left(\frac{350\ \text{days}}{\text{year}}\right) \times ED_{0\text{-}2}\left(2\ \text{years}\right) + EF_{2\text{-}6}\left(\frac{350\ \text{days}}{\text{year}}\right) \times ED_{2\text{-}6}\left(4\ \text{years}\right) + \\ EF_{6\text{-}16}\left(\frac{350\ \text{days}}{\text{year}}\right) \times ED_{6\text{-}16}\left(10\ \text{years}\right) + EF_{16\text{-}26}\left(\frac{350\ \text{days}}{\text{year}}\right) \times ED_{16\text{-}26}\left(10\ \text{years}\right) \end{array}}{ED_{0\text{-}2}\left(2\ \text{years}\right) + ED_{2\text{-}6}\left(4\ \text{years}\right) + ED_{6\text{-}16}\left(10\ \text{years}\right) + ED_{16\text{-}26}\left(10\ \text{years}\right)}$$

$$ET_{res}\left(\frac{24\ \text{hours}}{\text{day}}\right) = \frac{\begin{array}{c} ET_{0\text{-}2}\left(\frac{24\ \text{hours}}{\text{day}}\right) \times ED_{0\text{-}2}\left(2\ \text{years}\right) + ET_{2\text{-}6}\left(\frac{24\ \text{hours}}{\text{day}}\right) \times ED_{2\text{-}6}\left(4\ \text{years}\right) + \\ ET_{6\text{-}16}\left(\frac{24\ \text{hours}}{\text{day}}\right) \times ED_{6\text{-}16}\left(10\ \text{years}\right) + ET_{16\text{-}26}\left(\frac{24\ \text{hours}}{\text{day}}\right) \times ED_{16\text{-}26}\left(10\ \text{years}\right) \end{array}}{ED_{0\text{-}2}\left(2\ \text{years}\right) + ED_{2\text{-}6}\left(4\ \text{years}\right) + ED_{6\text{-}16}\left(10\ \text{years}\right) + ED_{16\text{-}26}\left(10\ \text{years}\right)}$$

A1.1.2 Groundwater/RSL Tapwater

Noncarcinogenic Child

Ingestion

$$SL_{water\text{-}nc\text{-}ing\text{-}c}\,(\mu g/L) = \frac{THQ \times AT_{res\text{-}c}\left(\frac{365\ days}{year} \times ED_{res\text{-}c}\,(6\ years)\right) \times BW_{res\text{-}c}\,(15\ kg) \times \left(\frac{1000\ \mu g}{mg}\right)}{EF_{res\text{-}c}\left(\frac{350\ days}{year}\right) \times ED_{res\text{-}c}\,(6\ years) \times \frac{1}{RfD_o\left(\frac{mg}{kg\text{-}d}\right)} \times IRW_{res\text{-}c}\left(\frac{0.78\ L}{day}\right)}$$

Dermal

FOR INORGANICS:

$$SL_{water\text{-}nc\text{-}der\text{-}c}\,(\mu g/L) = \frac{DA_{event}\left(\frac{ug}{cm^2\text{- }event}\right) \times \left(\frac{1000\ cm^3}{L}\right)}{K_p\left(\frac{cm}{hour}\right) \times ET_{event\text{-}res\text{-}c}\left(\frac{0.54\ hours}{event}\right)}$$

FOR ORGANICS:

$$\text{IF } ET_{event\text{-}res\text{-}c}\left(\frac{0.54\ hours}{event}\right) \le t^*\ (hours)\text{, then } SL_{water\text{-}nc\text{-}der}\,(\mu g/L) = \frac{DA_{event}\left(\frac{ug}{cm^2\text{- }event}\right) \times \left(\frac{1000\ cm^3}{L}\right)}{2 \times FA \times K_p\left(\frac{cm}{hour}\right)\sqrt{\frac{6 \times \tau_{event}\left(\frac{hours}{event}\right) \times ET_{event\text{-}res\text{-}c}\left(\frac{0.54\ hours}{event}\right)}{\pi}}}$$

or,

$$\text{IF } ET_{event\text{-}res\text{-}c}\left(\frac{0.54\ hours}{event}\right) > t^*\ (hours)\text{, then } SL_{water\text{-}nc\text{-}der}\,(\mu g/L) = \frac{DA_{event}\left(\frac{ug}{cm^2\text{- }event}\right) \times \left(\frac{1000\ cm^3}{L}\right)}{FA \times K_p\left(\frac{cm}{hour}\right) \times \left[\frac{ET_{event\text{-}res\text{-}c}\left(\frac{0.54\ hours}{event}\right)}{1+B} + 2 \times \tau_{event}\left(\frac{hours}{event}\right) \times \left(\frac{1+3B+3B^2}{(1+B)^2}\right)\right]}$$

where:

$$DA_{event}\left(\frac{ug}{cm^2\text{- }event}\right) = \frac{THQ \times AT_{res\text{-}c}\left(\frac{365\ days}{year} \times ED_{res\text{-}c}\,(6\ years)\right) \times \left(\frac{1000\ \mu g}{mg}\right) \times BW_{res\text{-}c}\,(15\ kg)}{\left[\frac{1}{RfD_o\left(\frac{mg}{kg\text{-}day}\right) \times GIABS}\right] \times EV_{res\text{-}c}\left(\frac{1\ events}{day}\right) \times ED_{res\text{-}c}\,(6\ years) \times EF_{res\text{-}c}\left(\frac{350\ days}{year}\right) \times SA_{res\text{-}c}\left(6365\ cm^2\right)}$$

Inhalation

$$SL_{water\text{-}nc\text{-}inh\text{-}c}\,(\mu g/L) = \frac{THQ \times AT_{res\text{-}c}\left(\frac{365\ days}{year} \times ED_{res\text{-}c}\,(6\ years)\right) \times \left(\frac{1000\ \mu g}{mg}\right)}{EF_{res\text{-}c}\left(\frac{350\ days}{year}\right) \times ED_{res\text{-}c}\,(6\ years) \times ET_{res\text{-}c}\left(\frac{24\ hours}{day}\right) \times \left(\frac{1\ day}{24\ hours}\right) \times \frac{1}{RfC\left(mg/m^3\right)} \times K\left(\frac{0.5\ L}{m^3}\right)}$$

Total

$$SL_{res\text{-}water\text{-}nc\text{-}tot\text{-}c}\,(\mu g/L) = \frac{1}{\frac{1}{SL_{water\text{-}nc\text{-}ing\text{-}c}} + \frac{1}{SL_{water\text{-}nc\text{-}der\text{-}c}} + \frac{1}{SL_{water\text{-}nc\text{-}inh\text{-}c}}}$$

Noncarcinogenic Adult

Ingestion

$$SL_{water\text{-}nc\text{-}ing\text{-}a}\,(\mu g/L) = \frac{THQ \times AT_{res\text{-}a}\left(\frac{365\ days}{year} \times ED_{res}\,(26\ years)\right) \times BW_{res\text{-}a}\,(80\ kg) \times \left(\frac{1000\ \mu g}{mg}\right)}{EF_{res\text{-}a}\left(350\ \frac{days}{year}\right) \times ED_{res}\,(26\ years) \times \frac{1}{RfD_o\left(\frac{mg}{kg\text{-}d}\right)} \times IRW_{res\text{-}a}\left(\frac{2.5\ L}{day}\right)}$$

Dermal

FOR INORGANICS:

$$SL_{water\text{-}nc\text{-}der\text{-}a}\,(\mu g/L) = \frac{DA_{event}\left(\frac{ug}{cm^2\text{-}\ event}\right) \times \left(\frac{1000\ cm^3}{L}\right)}{K_p\left(\frac{cm}{hour}\right) \times ET_{event\text{-}res\text{-}a}\left(\frac{0.71\ hours}{event}\right)}$$

FOR ORGANICS:

$$\text{IF } ET_{event\text{-}res\text{-}a}\left(\frac{0.71\ hours}{event}\right) \le t^*\ (hours), \text{then } SL_{water\text{-}nc\text{-}der}\,(\mu g/L) = \frac{DA_{event}\left(\frac{ug}{cm^2\text{-}\ event}\right) \times \left(\frac{1000\ cm^3}{L}\right)}{2 \times FA \times K_p\left(\frac{cm}{hour}\right)\sqrt{\frac{6 \times \tau_{event}\left(\frac{hours}{event}\right) \times ET_{event\text{-}res\text{-}a}\left(\frac{0.71\ hours}{event}\right)}{\pi}}}$$

or,

$$\text{IF } ET_{event\text{-}res\text{-}a}\left(\frac{0.71\ hours}{event}\right) > t^*\ (hours), \text{then } SL_{water\text{-}nc\text{-}der}\,(\mu g/L) = \frac{DA_{event}\left(\frac{ug}{cm^2\text{-}\ event}\right) \times \left(\frac{1000\ cm^3}{L}\right)}{FA \times K_p\left(\frac{cm}{hour}\right) \times \left[\frac{ET_{event\text{-}res\text{-}a}\left(\frac{0.71\ hours}{event}\right)}{1+B} + 2 \times \tau_{event}\left(\frac{hours}{event}\right) \times \left(\frac{1+3B+3B^2}{(1+B)^2}\right)\right]}$$

where:

$$DA_{event}\left(\frac{ug}{cm^2\text{-}\ event}\right) = \frac{THQ \times AT_{res\text{-}a}\left(\frac{365\ days}{year} \times ED_{res}\,(26\ years)\right) \times \left(\frac{1000\ \mu g}{mg}\right) \times BW_{res\text{-}a}\,(80\ kg)}{\left(\frac{1}{RfD_o\left(\frac{mg}{kg\text{-}day}\right) \times GIABS}\right) \times EV_{res\text{-}a}\left(\frac{1\ events}{day}\right) \times ED_{res}\,(26\ years) \times EF_{res\text{-}a}\left(\frac{350\ days}{year}\right) \times SA_{res\text{-}a}\left(19652\ cm^2\right)}$$

Inhalation

$$SL_{water\text{-}nc\text{-}inh\text{-}a}\,(\mu g/L) = \frac{THQ \times AT_{res\text{-}a}\left(\frac{365\ days}{year} \times ED_{res}\,(26\ years)\right) \times \left(\frac{1000\ \mu g}{mg}\right)}{EF_{res\text{-}a}\left(\frac{350\ days}{year}\right) \times ED_{res}\,(26\ years) \times ET_{res\text{-}a}\left(\frac{24\ hours}{day}\right) \times \left(\frac{1\ day}{24\ hours}\right) \times \frac{1}{RfC\left(mg/m^3\right)} \times K\left(\frac{0.5\ L}{m^3}\right)}$$

Carcinogenic

Ingestion

$$SL_{water\text{-}ca\text{-}ing}\left(\mu g/L\right) = \frac{TR \times AT_{res}\left(\frac{365\ days}{year} \times LT\left(70\ years\right)\right) \times \left(\frac{1000\ \mu g}{mg}\right)}{CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1} \times \left(IFW_{res\text{-}adj}\left(\frac{327.95\ L}{kg}\right)\right)}$$

where:

$$IFW_{res\text{-}adj}\left(\frac{327.95\ L}{kg}\right) = \left(\frac{EF_{res\text{-}c}\left(\frac{350\ days}{year}\right) \times ED_{res\text{-}c}\left(6\ years\right) \times IRW_{res\text{-}c}\left(\frac{0.78\ L}{day}\right)}{BW_{res\text{-}c}\left(15\ kg\right)} + \frac{EF_{res\text{-}a}\left(\frac{350\ days}{year}\right) \times \left(ED_{res}\left(26\ years\right) - ED_{res\text{-}c}\left(6\ years\right)\right) \times IRW_{res\text{-}a}\left(\frac{2.5\ L}{day}\right)}{BW_{res\text{-}a}\left(80\ kg\right)}\right)$$

Dermal

FOR INORGANICS:

$$SL_{water\text{-}ca\text{-}der}\left(\mu g/L\right) = \frac{DA_{event}\left(\frac{ug}{cm^2\text{-}\ event}\right) \times \left(\frac{1000\ cm^3}{L}\right)}{K_p\left(\frac{cm}{hour}\right) \times ET_{event\text{-}res\text{-}adj}\left(\frac{0.6708\ hours}{event}\right)}$$

FOR ORGANICS:

$$\text{IF } ET_{event\text{-}res\text{-}adj}\left(\frac{hours}{event}\right) \le t^*\ (hours), \text{then } SL_{water\text{-}ca\text{-}der}\left(\mu g/L\right) = \frac{DA_{event}\left(\frac{ug}{cm^2\text{-}\ event}\right) \times \left(\frac{1000\ cm^3}{L}\right)}{2 \times FA \times K_p\left(\frac{cm}{hour}\right)\sqrt{\frac{6 \times \tau_{event}\left(\frac{hours}{event}\right) \times ET_{event\text{-}res\text{-}adj}\left(\frac{0.6708\ hours}{event}\right)}{\pi}}}$$

or,

$$\text{IF } ET_{event\text{-}res\text{-}adj}\left(\frac{hours}{event}\right) > t^*\ (hours), \text{then } SL_{water\text{-}ca\text{-}der}\left(\mu g/L\right) = \frac{DA_{event}\left(\frac{ug}{cm^2\text{-}\ event}\right) \times \left(\frac{1000\ cm^3}{L}\right)}{FA \times K_p\left(\frac{cm}{hour}\right) \times \left[\frac{ET_{event\text{-}res\text{-}adj}\left(\frac{0.6708\ hours}{event}\right)}{1+B} + 2 \times \tau_{event}\left(\frac{hours}{event}\right) \times \left(\frac{1+3B+3B^2}{(1+B)^2}\right)\right]}$$

where:

$$DA_{event}\left(\frac{ug}{cm^2\text{-}\ event}\right) = \frac{TR \times AT_{res}\left(\frac{365\ days}{year} \times LT\left(70\ years\right)\right) \times \left(\frac{1000\ \mu g}{mg}\right)}{\left(\frac{CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1}}{GIABS}\right) \times DFW_{res\text{-}adj}\left(\frac{2{,}610{,}650\ events\text{-}cm^2}{kg}\right)}$$

where:

$$DFW_{res\text{-}adj}\left(\frac{2{,}610{,}650\ events\text{-}cm^2}{kg}\right) = \left(\frac{EF_{res\text{-}c}\left(\frac{350\ days}{year}\right) \times EV_{res\text{-}c}\left(\frac{1\ events}{day}\right) \times ED_{res\text{-}c}\left(6\ years\right) \times SA_{res\text{-}c}\left(6365\ cm^2\right)}{BW_{reswc}\left(15\ kg\right)} + \frac{EF_{res\text{-}a}\left(\frac{350\ days}{year}\right) \times EV_{res\text{-}a}\left(\frac{1\ events}{day}\right) \times \left(ED_{res}\left(26\ years\right) - ED_{res\text{-}c}\left(6\ years\right)\right) \times SA_{res\text{-}a}\left(19652\ cm^2\right)}{BW_{res\text{-}a}\left(80\ kg\right)}\right)$$

and:

$$ET_{event\text{-}res\text{-}adj}\left(\frac{0.6708\ hours}{event}\right) = \left(\frac{\left(ET_{event\text{-}res\text{-}c}\left(\frac{0.54\ hours}{event}\right) \times ED_{res\text{-}c}\left(6\ years\right) + ET_{event\text{-}res\text{-}a}\left(\frac{0.71\ hours}{event}\right) \times \left(ED_{res}\left(26\ years\right) - ED_{res\text{-}c}\left(6\ years\right)\right)\right)}{ED_{res}\left(26\ years\right)}\right)$$

Inhalation

$$SL_{water\text{-}ca\text{-}inh}\left(\mu g/L\right) = \frac{TR \times AT_{res}\left(\frac{365\ days}{year} \times LT\left(70\ years\right)\right)}{EF_{res}\left(\frac{350\ days}{year}\right) \times ED_{res}\left(26\ years\right) \times ET_{res}\left(\frac{24\ hours}{day}\right) \times \left(\frac{1\ day}{24\ hours}\right) \times IUR\left(\mu g/m^3\right)^{-1} \times K\left(\frac{0.5\ L}{m^3}\right)}$$

Total

$$SL_{water\text{-}ca\text{-}tot}\left(\mu g/L\right) = \frac{1}{\frac{1}{SL_{water\text{-}ca\text{-}ing}} + \frac{1}{SL_{water\text{-}ca\text{-}der}} + \frac{1}{SL_{water\text{-}ca\text{-}inh}}}$$

Mutagenic

Ingestion

$$SL_{water\text{-}mu\text{-}ing}\left(\mu g/L\right) = \frac{TR \times AT_{res}\left(\frac{365\ days}{year} \times LT\left(70\ years\right)\right) \times \left(\frac{1000\ \mu g}{mg}\right)}{CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1} \times IFWM_{res\text{-}adj}\left(\frac{1019.9\ L}{kg}\right)}$$

where:

$$IFWM_{res\text{-}adj}\left(\frac{1019.9\ L}{kg}\right) = \left(\begin{array}{l} \frac{EF_{0\text{-}2}\left(\frac{350\ days}{year}\right) \times ED_{0\text{-}2}\left(years\right) \times IRW_{0\text{-}2}\left(\frac{0.78\ L}{day}\right) \times 10}{BW_{0\text{-}2}\left(15\ kg\right)} + \\ \frac{EF_{2\text{-}6}\left(\frac{350\ days}{year}\right) \times ED_{2\text{-}6}\left(years\right) \times IRW_{2\text{-}6}\left(\frac{0.78\ L}{day}\right) \times 3}{BW_{2\text{-}6}\left(15\ kg\right)} + \\ \frac{EF_{6\text{-}16}\left(\frac{350\ days}{year}\right) \times ED_{6\text{-}16}\left(years\right) \times IRW_{6\text{-}16}\left(\frac{2.5\ L}{day}\right) \times 3}{BW_{6\text{-}16}\left(80\ kg\right)} + \\ \frac{EF_{16\text{-}26}\left(\frac{350\ days}{year}\right) \times ED_{16\text{-}26}\left(years\right) \times IRW_{16\text{-}26}\left(\frac{2.5\ L}{day}\right) \times 1}{BW_{16\text{-}26}\left(80\ kg\right)} \end{array}\right)$$

Dermal

FOR INORGANICS:

$$SL_{water\text{-}mu\text{-}der}\,(\mu g/L) = \frac{DA_{event}\left(\frac{ug}{cm^2\text{-}event}\right) \times \left(\frac{1000\ cm^3}{L}\right)}{K_p\left(\frac{cm}{hour}\right) \times ET_{event\text{-}res\text{-}madj}\left(\frac{0.6708\ hours}{event}\right)}$$

FOR ORGANICS:

$$\text{IF } ET_{event\text{-}res\text{-}madj}\left(\frac{0.6708\ hours}{event}\right) \le t^*\ (hours), \text{then } SL_{water\text{-}mu\text{-}der}\,(\mu g/L) = \frac{DA_{event}\left(\frac{ug}{cm^2\text{-}event}\right) \times \left(\frac{1000\ cm^3}{L}\right)}{2 \times FA \times K_p\left(\frac{cm}{hour}\right)\sqrt{\frac{6 \times \tau_{event}\left(\frac{hours}{event}\right) \times ET_{event\text{-}res\text{-}madj}\left(\frac{hours}{event}\right)}{\pi}}}$$

or,

$$\text{IF } ET_{event\text{-}res\text{-}madj}\left(\frac{0.6708\ hours}{event}\right) > t^*\ (hours), \text{then } SL_{water\text{-}mu\text{-}der}\,(\mu g/L) = \frac{DA_{event}\left(\frac{ug}{cm^2\text{-}event}\right) \times \left(\frac{1000\ cm^3}{L}\right)}{FA \times K_p\left(\frac{cm}{hour}\right) \times \left[\frac{ET_{event\text{-}res\text{-}madj}\left(\frac{hours}{event}\right)}{1+B} + 2 \times \tau_{event}\left(\frac{hours}{event}\right) \times \left(\frac{1+3B+3B^2}{(1+B)^2}\right)\right]}$$

where:

$$DA_{event}\left(\frac{ug}{cm^2\text{-}event}\right) = \frac{TR \times AT_{res}\left(\frac{365\ days}{year} \times LT\,(70\ years)\right) \times \left(\frac{1000\ \mu g}{mg}\right)}{\left(\frac{CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1}}{GIABS}\right) \times DFWM_{res\text{-}adj}\left(\frac{8{,}191{,}633\ events\text{-}cm^2}{kg}\right)}$$

where:

$$DFWM_{res\text{-}adj}\left(\frac{8{,}191{,}633\ events\text{-}cm^2}{kg}\right) = \left[\begin{array}{l} \left(\frac{EV_{0\text{-}2}\left(\frac{1\ events}{day}\right) \times EF_{0\text{-}2}\left(\frac{350\ days}{year}\right) \times ED_{0\text{-}2}\,(years) \times SA_{0\text{-}2}\left(6365\ cm^2\right) \times 10}{BW_{0\text{-}2}\,(15\ kg)}\right) + \\ \left(\frac{EV_{2\text{-}6}\left(\frac{1\ events}{day}\right) \times EF_{2\text{-}6}\left(\frac{350\ days}{year}\right) \times ED_{2\text{-}6}\,(years) \times SA_{2\text{-}6}\left(6365\ cm^2\right) \times 3}{BW_{2\text{-}6}\,(15\ kg)}\right) + \\ \left(\frac{EV_{6\text{-}16}\left(\frac{1\ events}{day}\right) \times EF_{6\text{-}16}\left(\frac{350\ days}{year}\right) \times ED_{6\text{-}16}\,(years) \times SA_{6\text{-}16}\left(19652\ cm^2\right) \times 3}{BW_{6\text{-}16}\,(80\ kg)}\right) + \\ \left(\frac{EV_{16\text{-}26}\left(\frac{1\ events}{day}\right) \times EF_{16\text{-}26}\left(\frac{350\ days}{year}\right) \times ED_{16\text{-}26}\,(years) \times SA_{16\text{-}26}\left(19652\ cm^2\right) \times 1}{BW_{16\text{-}26}\,(80\ kg)}\right) \end{array}\right]$$

and:

$$ET_{event\text{-}res\text{-}madj}\left(\frac{0.6708\ hours}{event}\right) = \frac{\left(\begin{array}{l} ET_{event\text{-}res\,(0\text{-}2)}\left(\frac{0.54\ hours}{event}\right) \times ED_{0\text{-}2}\,(2\ years) + ET_{event\text{-}res\,(2\text{-}6)}\left(\frac{0.54\ hours}{event}\right) \times ED_{2\text{-}6}\,(4\ years) + \\ ET_{event\text{-}res\,(6\text{-}16)}\left(\frac{0.71\ hours}{event}\right) \times ED_{6\text{-}16}\,(10\ years) + ET_{event\text{-}res\,(16\text{-}26)}\left(\frac{0.71\ hours}{event}\right) \times ED_{16\text{-}26}\,(10\ years) \end{array}\right)}{ED_{0\text{-}2}\,(2\ years) + ED_{2\text{-}6}\,(4\ years) + ED_{6\text{-}16}\,(10\ years) + ED_{16\text{-}26}\,(10\ years)}$$

Inhalation

$$SL_{water\text{-}mu\text{-}inh}\left(\mu g/L\right) = \frac{TR \times AT_{res}\left(\frac{365\ days}{year} \times LT\left(70\ years\right)\right)}{IUR\left(\mu g/m^{3}\right)^{-1} \times K\left(\frac{0.5\ L}{m^{3}}\right) \times \left(\begin{array}{l}\left(EF_{0\text{-}2}\left(\frac{350\ days}{year}\right) \times ET_{0\text{-}2}\left(\frac{24\ hours}{day}\right) \times \left(\frac{1\ day}{24\ hours}\right) \times ED_{0\text{-}2}\left(2\ years\right) \times 10\right) + \\ \left(EF_{2\text{-}6}\left(\frac{350\ days}{year}\right) \times ET_{2\text{-}6}\left(\frac{24\ hours}{day}\right) \times \left(\frac{1\ day}{24\ hours}\right) \times ED_{2\text{-}6}\left(4\ years\right) \times 3\right) + \\ \left(EF_{6\text{-}16}\left(\frac{350\ days}{year}\right) \times ET_{6\text{-}16}\left(\frac{24\ hours}{day}\right) \times \left(\frac{1\ day}{24\ hours}\right) \times ED_{6\text{-}16}\left(10\ years\right) \times 3\right) + \\ \left(EF_{16\text{-}26}\left(\frac{350\ days}{year}\right) \times ET_{16\text{-}26}\left(\frac{24\ hours}{day}\right) \times \left(\frac{1\ day}{24\ hours}\right) \times ED_{16\text{-}26}\left(10\ years\right) \times 1\right)\end{array}\right)}$$

Total

$$SL_{water\text{-}mu\text{-}tot}\left(\mu g/L\right) = \frac{1}{\frac{1}{SL_{water\text{-}mu\text{-}ing}} + \frac{1}{SL_{water\text{-}mu\text{-}der}} + \frac{1}{SL_{water\text{-}mu\text{-}inh}}}$$

<u>**Vinyl Chloride**</u>

Ingestion

$$SL_{water\text{-}ca\text{-}vc\text{-}ing}\left(\mu g/L\right) = \frac{TR}{\left(\frac{CSF_{o}\left(\frac{mg}{kg\text{-}day}\right)^{-1} \times IFW_{res\text{-}adj}\left(\frac{327.95\ L}{kg}\right) \times \left(\frac{mg}{1000\ \mu g}\right)}{AT_{res}\left(\frac{365\ days}{year} \times LT\left(70\ years\right)\right)}\right) + \left(\frac{CSF_{o}\left(\frac{mg}{kg\text{-}day}\right)^{-1} \times IRW_{res\text{-}c}\left(\frac{0.78\ L}{day}\right) \times \left(\frac{mg}{1000\ \mu g}\right)}{BW_{res\text{-}c}\left(15\ kg\right)}\right)}$$

where:

$$IFW_{res\text{-}adj}\left(\frac{327.95\ L}{kg}\right) = \left(\begin{array}{l}\frac{EF_{res\text{-}c}\left(\frac{350\ days}{year}\right) \times ED_{res\text{-}c}\left(6\ years\right) \times IRW_{res\text{-}c}\left(\frac{0.78\ L}{day}\right)}{BW_{res\text{-}c}\left(15\ kg\right)} + \\ \frac{EF_{res\text{-}a}\left(\frac{350\ days}{year}\right) \times \left(ED_{res}\left(26\ years\right) - ED_{res\text{-}c}\left(6\ years\right)\right) \times IRW_{res\text{-}a}\left(\frac{2.5\ L}{day}\right)}{BW_{res\text{-}a}\left(80\ kg\right)}\end{array}\right)$$

Dermal

$$\text{IF } ET_{event\text{-}res\text{-}adj}\left(\frac{0.6708\ \text{hours}}{\text{event}}\right) \le t^{*}\ (\text{hours}) \text{ then } SL_{water\text{-}vc\text{-}der}\left(\mu g/L\right) = \frac{DA_{event}\left(\frac{ug}{cm^{2}\text{-}\ event}\right)\times\left(\frac{1000\ cm^{3}}{L}\right)}{2\times FA\times K_{p}\left(\frac{cm}{hour}\right)\sqrt{\frac{6\times\tau_{event}\left(\frac{hours}{event}\right)\times ET_{event\text{-}res\text{-}adj}\left(\frac{0.6708\ hours}{event}\right)}{\pi}}}$$

or,

$$\text{IF } ET_{event\text{-}res\text{-}adj}\left(\frac{0.6708\ \text{hours}}{\text{event}}\right) > t^{*}\ (\text{hours}), \text{then } SL_{water\text{-}vc\text{-}der}\left(\mu g/L\right) = \frac{DA_{event}\left(\frac{ug}{cm^{2}\text{-}\ event}\right)\times\left(\frac{1000\ cm^{3}}{L}\right)}{FA\times K_{p}\left(\frac{cm}{hour}\right)\times\left[\frac{ET_{event\text{-}res\text{-}adj}\left(\frac{0.6708\ hours}{event}\right)}{1+B}+2\times\tau_{event}\left(\frac{hours}{event}\right)\times\left(\frac{1+3B+3B^{2}}{(1+B)^{2}}\right)\right]}$$

where:

$$DA_{event}\left(\frac{ug}{cm^{2}\text{-}\ event}\right) = \frac{TR}{\left(\frac{\left(\frac{CSF_{o}\left(\frac{mg}{kg\text{-}day}\right)^{-1}}{GIABS}\right)\times DFW_{res\text{-}adj}\left(\frac{2{,}610{,}650\ events\text{-}cm^{2}}{kg}\right)}{AT_{res}\left(\frac{365\ days}{year}\times LT\ (70\ years)\right)\times\left(\frac{1000\ \mu g}{mg}\right)}\right)+\left(\frac{\left(\frac{CSF_{o}\left(\frac{mg}{kg\text{-}day}\right)^{-1}}{GIABS}\right)\times EV_{res\text{-}c}\left(\frac{1\ events}{day}\right)\times SA_{res\text{-}c}\left(6365\ cm^{2}\right)}{BW_{res\text{-}c}\ (15\ kg)\times\left(\frac{1000\ \mu g}{mg}\right)}\right)}$$

where:

$$DFW_{res\text{-}adj}\left(\frac{2{,}610{,}650\ events\text{-}cm^{2}}{kg}\right) = \left(\frac{EF_{res\text{-}c}\left(\frac{350\ days}{year}\right)\times EV_{res\text{-}c}\left(\frac{1\ events}{day}\right)\times ED_{res\text{-}c}\ (6\ years)\times SA_{res\text{-}c}\left(6365\ cm^{2}\right)}{BW_{res\text{-}c}\ (15\ kg)}+\frac{EF_{res\text{-}a}\left(\frac{350\ days}{year}\right)\times EV_{res\text{-}a}\left(\frac{1\ events}{day}\right)\times ED_{res\text{-}a}\ (20\ years)\times SA_{res\text{-}a}\left(19652\ cm^{2}\right)}{BW_{res\text{-}a}\ (80\ kg)}\right)$$

and:

$$ET_{event\text{-}res\text{-}adj}\left(\frac{0.6708\ hours}{event}\right) = \left(\frac{\left(ET_{event\text{-}res\text{-}c}\left(\frac{0.54\ hours}{event}\right)\times ED_{res\text{-}c}\ (6\ years)+ET_{event\text{-}res\text{-}a}\left(\frac{0.71\ hours}{event}\right)\times\left(ED_{res}\ (26\ years)-ED_{res\text{-}c}\ (6\ years)\right)\right)}{ED_{res}\ (26\ years)}\right)$$

Inhalation

$$SL_{water\text{-}ca\text{-}vc\text{-}inh}\left(\mu g/L\right) = \frac{TR}{\left(\frac{IUR\left(\mu g/m^{3}\right)^{-1}\times EF_{res}\left(\frac{350\ days}{year}\right)\times ED_{res}\ (26\ years)\times ET_{res}\left(\frac{24\ hours}{day}\right)\times\left(\frac{1\ day}{24\ hours}\right)\times K\left(\frac{0.5\ L}{m^{3}}\right)}{AT_{res}\left(\frac{365\ days}{year}\times LT\ (70\ years)\right)}\right)+\left(IUR\left(\mu g/m^{3}\right)^{-1}\times K\left(\frac{0.5\ L}{m^{3}}\right)\right)}$$

Total

$$SL_{water\text{-}ca\text{-}vc\text{-}tot}\left(\mu g/L\right) = \frac{1}{\frac{1}{SL_{water\text{-}ca\text{-}vc\text{-}ing}}+\frac{1}{SL_{water\text{-}ca\text{-}vc\text{-}der}}+\frac{1}{SL_{water\text{-}ca\text{-}vc\text{-}inh}}}$$

Trichloroethylene

Ingestion

$$SL_{water\text{-}tce\text{-}ing}\left(\mu g/L\right) = \frac{TR \times AT_{res}\left(\frac{365\ days}{year} \times LT\left(70\ years\right)\right) \times \left(\frac{1000\ \mu g}{mg}\right)}{CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1} \times \left(\left(CAF_o\left(0.804\right) \times IFW_{res\text{-}adj}\left(\frac{327.95\ L}{kg}\right)\right)\right) + \left(MAF_o\left(0.202\right) \times IFWM_{res\text{-}adj}\left(\frac{1019.9\ L}{kg}\right)\right)}$$

where:

$$IFW_{res\text{-}adj}\left(\frac{327.95\ L}{kg}\right) = \left(\begin{array}{l} \frac{ED_{res\text{-}c}\left(6\ years\right) \times EF_{res\text{-}c}\left(\frac{350\ days}{year}\right) \times IRW_{res\text{-}c}\left(\frac{0.78\ L}{day}\right)}{BW_{res\text{-}c}\left(15\ kg\right)} + \\ \frac{\left(ED_{res}\left(26\ years\right) - ED_{res\text{-}c}\left(6\ years\right)\right) \times EF_{res\text{-}a}\left(\frac{350\ days}{year}\right) \times IRW_{res\text{-}a}\left(\frac{2.5\ L}{day}\right)}{BW_{res\text{-}a}\left(80\ kg\right)} \end{array}\right)$$

where:

$$IFWM_{res\text{-}adj}\left(\frac{1019.9\ L}{kg}\right) = \left(\begin{array}{l} \frac{ED_{0\text{-}2}\left(2\ years\right) \times EF_{0\text{-}2}\left(\frac{350\ days}{year}\right) \times IRW_{0\text{-}2}\left(\frac{0.78\ L}{day}\right) \times 10}{BW_{0\text{-}2}\left(15\ kg\right)} + \\ \frac{ED_{2\text{-}6}\left(4\ years\right) \times EF_{2\text{-}6}\left(\frac{350\ days}{year}\right) \times IRW_{2\text{-}6}\left(\frac{0.78\ L}{day}\right) \times 3}{BW_{2\text{-}6}\left(15\ kg\right)} + \\ \frac{ED_{6\text{-}16}\left(10\ years\right) \times EF_{6\text{-}16}\left(\frac{350\ days}{year}\right) \times IRW_{6\text{-}16}\left(\frac{2.5\ L}{day}\right) \times 3}{BW_{6\text{-}16}\left(80\ kg\right)} + \\ \frac{ED_{16\text{-}26}\left(10\ years\right) \times EF_{16\text{-}26}\left(\frac{350\ days}{year}\right) \times IRW_{16\text{-}26}\left(\frac{2.5\ L}{day}\right) \times 1}{BW_{16\text{-}26}\left(80\ kg\right)} \end{array}\right)$$

Dermal

FOR ORGANICS:

$$\text{IF } ET_{event\text{-}res\text{-}adj}\left(\frac{hours}{event}\right) \le t^{*}\ (hours)\text{, then } SL_{water\text{-}tce\text{-}der}\ (\mu g/L) = \frac{DA_{tce\text{-}event}\left(\frac{ug}{cm^2\text{-}event}\right) \times \left(\frac{1000\ cm^3}{L}\right)}{2 \times FA \times K_p\left(\frac{cm}{hour}\right)\sqrt{\frac{6 \times \tau_{event}\left(\frac{hours}{event}\right) \times ET_{event\text{-}res\text{-}adj}\left(\frac{0.6708\ hours}{event}\right)}{\pi}}}$$

or,

$$\text{IF } ET_{event\text{-}res\text{-}adj}\left(\frac{hours}{event}\right) > t^{*}\ (hours)\text{, then } SL_{water\text{-}tce\text{-}der}\ (\mu g/L) = \frac{DA_{tce\text{-}event}\left(\frac{ug}{cm^2\text{-}event}\right) \times \left(\frac{1000\ cm^3}{L}\right)}{FA \times K_p\left(\frac{cm}{hour}\right) \times \left[\frac{ET_{event\text{-}res\text{-}adj}\left(\frac{0.6708\ hours}{event}\right)}{1+B} + 2 \times \tau_{event}\left(\frac{hours}{event}\right) \times \left(\frac{1+3B+3B^2}{(1+B)^2}\right)\right]}$$

where:

$$DA_{tce\text{-}event}\left(\frac{ug}{cm^2\text{-}event}\right) = \frac{TR \times AT_{res}\left(\frac{365\ days}{year} \times LT\ (70\ years)\right) \times \left(\frac{1000\ \mu g}{mg}\right)}{\frac{CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1}}{GIABS} \times \left(\left(CAF_o\ (0.804) \times DFW_{res\text{-}adj}\left(\frac{2{,}610{,}650\ events\text{-}cm^2}{kg}\right)\right) + \left(MAF_o\ (0.202) \times DFWM_{res\text{-}adj}\left(\frac{8{,}191{,}633\ events\text{-}cm^2}{kg}\right)\right)\right)}$$

where:

$$DFW_{res\text{-}adj}\left(\frac{2{,}610{,}650\ events\text{-}cm^2}{kg}\right) = \left(\frac{EV_{res\text{-}c}\left(\frac{1\ events}{day}\right) \times ED_{res\text{-}c}\ (6\ years) \times EF_{res\text{-}c}\left(\frac{350\ days}{year}\right) \times SA_{res\text{-}c}\left(6365\ cm^2\right)}{BW_{res\text{-}c}\ (15\ kg)} + \frac{EV_{res\text{-}a}\left(\frac{1\ events}{day}\right) \times ED_{res\text{-}a}\ (20\ years) \times EF_{res\text{-}a}\left(\frac{350\ days}{year}\right) \times SA_{res\text{-}a}\left(19652\ cm^2\right)}{BW_{res\text{-}a}\ (80\ kg)}\right)$$

where:

$$DFWM_{res\text{-}adj}\left(\frac{8{,}191{,}633\ events\text{-}cm^2}{kg}\right) = \left[\begin{array}{l} \left(\frac{EV_{0\text{-}2}\left(\frac{1\ events}{day}\right) \times ED_{0\text{-}2}\ (2\ years) \times EF_{0\text{-}2}\left(\frac{350\ days}{year}\right) \times SA_{0\text{-}2}\left(6365\ cm^2\right) \times 10}{BW_{0\text{-}2}\ (15\ kg)}\right) + \\ \left(\frac{EV_{2\text{-}6}\left(\frac{1\ events}{day}\right) \times ED_{2\text{-}6}\ (4\ years) \times EF_{2\text{-}6}\left(\frac{350\ days}{year}\right) \times SA_{2\text{-}6}\left(6365\ cm^2\right) \times 3}{BW_{2\text{-}6}\ (15\ kg)}\right) + \\ \left(\frac{EV_{6\text{-}16}\left(\frac{1\ events}{day}\right) \times ED_{6\text{-}16}\ (10\ years) \times EF_{6\text{-}16}\left(\frac{350\ days}{year}\right) \times SA_{6\text{-}16}\left(19652\ cm^2\right) \times 3}{BW_{6\text{-}16}\ (80\ kg)}\right) + \\ \left(\frac{EV_{16\text{-}26}\left(\frac{1\ events}{day}\right) \times ED_{16\text{-}26}\ (10\ years) \times EF_{16\text{-}26}\left(\frac{350\ days}{year}\right) \times SA_{16\text{-}26}\left(19652\ cm^2\right) \times 1}{BW_{16\text{-}26}\ (80\ kg)}\right) \end{array}\right]$$

and:

$$ET_{event\text{-}res\text{-}adj}\left(\frac{0.6708\ hours}{event}\right) = \frac{\left(\begin{array}{l} ET_{event\text{-}res(0\text{-}2)}\left(\frac{0.54\ hours}{event}\right) \times ED_{0\text{-}2}\ (2\ years) + ET_{event\text{-}res(2\text{-}6)}\left(\frac{0.54\ hours}{event}\right) \times ED_{2\text{-}6}\ (4\ years) + \\ ET_{event\text{-}res(6\text{-}16)}\left(\frac{0.71\ hours}{event}\right) \times ED_{6\text{-}16}\ (10\ years) + ET_{event\text{-}res(16\text{-}26)}\left(\frac{0.71\ hours}{event}\right) \times ED_{16\text{-}26}\ (10\ years) \end{array}\right)}{ED_{0\text{-}2}\ (2\ years) + ED_{2\text{-}6}\ (4\ years) + ED_{6\text{-}16}\ (10\ years) + ED_{16\text{-}26}\ (10\ years)}$$

Inhalation

$$SL_{water\text{-}tce\text{-}inh}\left(\mu g/L\right)=\frac{TR\times AT_{res}\left(\frac{365\ days}{year}\times LT\left(70\ years\right)\right)}{IUR\left(\frac{\mu g}{m^3}\right)^{-1}\times K\left(\frac{0.5\ L}{m^3}\right)\times\left(\begin{array}{l}\left(EF_{res}\left(\frac{350\ days}{year}\right)\times ED_{res}\left(26\ years\right)\times ET_{res}\left(\frac{24\ hours}{day}\right)\times\left(\frac{1\ day}{24\ hours}\right)\times CAF_i\left(0.756\right)\right)+\\ \left(\left(\begin{array}{l}\left(ED_{0\text{-}2}\left(2\ years\right)\times EF_{0\text{-}2}\left(\frac{350\ days}{year}\right)\times ET_{0\text{-}2}\left(\frac{24\ hours}{day}\right)\times\left(\frac{1\ day}{24\ hours}\right)\times MAF_i\left(0.244\right)\times 10\right)+\\ \left(ED_{2\text{-}6}\left(4\ years\right)\times EF_{2\text{-}6}\left(\frac{350\ days}{year}\right)\times ET_{2\text{-}6}\left(\frac{24\ hours}{day}\right)\times\left(\frac{1\ day}{24\ hours}\right)\times MAF_i\left(0.244\right)\times 3\right)+\\ \left(ED_{6\text{-}16}\left(10\ years\right)\times EF_{6\text{-}16}\left(\frac{350\ days}{year}\right)\times ET_{6\text{-}16}\left(\frac{24\ hours}{day}\right)\times\left(\frac{1\ day}{24\ hours}\right)\times MAF_i\left(0.244\right)\times 3\right)+\\ \left(ED_{16\text{-}26}\left(10\ years\right)\times EF_{16\text{-}26}\left(\frac{350\ days}{year}\right)\times ET_{16\text{-}26}\left(\frac{24\ hours}{day}\right)\times\left(\frac{1\ day}{24\ hours}\right)\times MAF_i\left(0.244\right)\times 1\right)\end{array}\right)\right)\end{array}\right)}$$

Total

$$SL_{water\text{-}tce\text{-}tot}\left(\mu g/L\right)=\frac{1}{\frac{1}{SL_{water\text{-}tce\text{-}ing}}+\frac{1}{SL_{water\text{-}tce\text{-}der}}+\frac{1}{SL_{water\text{-}tce\text{-}inh}}}$$

Supporting Equations

Child

$$ED_{res\text{-}c}\left(6\ \text{years}\right) = ED_{0\text{-}2}\left(2\ \text{years}\right) + ED_{2\text{-}6}\left(4\ \text{years}\right)$$

$$BW_{res\text{-}c}\left(15\ \text{kg}\right) = \frac{BW_{0\text{-}2}\left(15\ \text{kg}\right) \times ED_{0\text{-}2}\left(2\ \text{years}\right) + BW_{2\text{-}6}\left(15\ \text{kg}\right) \times ED_{2\text{-}6}\left(4\ \text{years}\right)}{ED_{0\text{-}2}\left(2\ \text{years}\right) + ED_{2\text{-}6}\left(4\ \text{years}\right)}$$

$$EV_{res\text{-}c}\left(\frac{1\ \text{event}}{\text{day}}\right) = \frac{EV_{0\text{-}2}\left(\frac{1\ \text{event}}{\text{day}}\right) \times ED_{0\text{-}2}\left(2\ \text{years}\right) + EV_{2\text{-}6}\left(\frac{1\ \text{event}}{\text{day}}\right) \times ED_{2\text{-}6}\left(4\ \text{years}\right)}{ED_{0\text{-}2}\left(2\ \text{years}\right) + ED_{2\text{-}6}\left(4\ \text{years}\right)}$$

$$EF_{res\text{-}c}\left(\frac{350\ \text{days}}{\text{year}}\right) = \frac{EF_{0\text{-}2}\left(\frac{350\ \text{days}}{\text{year}}\right) \times ED_{0\text{-}2}\left(2\ \text{years}\right) + EF_{2\text{-}6}\left(\frac{350\ \text{days}}{\text{year}}\right) \times ED_{2\text{-}6}\left(4\ \text{years}\right)}{ED_{0\text{-}2}\left(2\ \text{years}\right) + ED_{2\text{-}6}\left(4\ \text{years}\right)}$$

$$ET_{event\text{-}res\text{-}c}\left(\frac{0.54\ \text{hours}}{\text{event}}\right) = \frac{ET_{event\,(0\text{-}2)}\left(\frac{0.54\ \text{hours}}{\text{event}}\right) \times ED_{0\text{-}2}\left(2\ \text{years}\right) + ET_{event\,(2\text{-}4)}\left(\frac{0.54\ \text{hours}}{\text{event}}\right) \times ED_{2\text{-}6}\left(4\ \text{years}\right)}{ED_{0\text{-}2}\left(2\ \text{years}\right) + ED_{2\text{-}6}\left(4\ \text{years}\right)}$$

$$ET_{res\text{-}c}\left(\frac{24\ \text{hours}}{\text{day}}\right) = \frac{ET_{0\text{-}2}\left(\frac{24\ \text{hours}}{\text{day}}\right) \times ED_{0\text{-}2}\left(2\ \text{years}\right) + ET_{2\text{-}6}\left(\frac{24\ \text{hours}}{\text{day}}\right) \times ED_{2\text{-}6}\left(4\ \text{years}\right)}{ED_{0\text{-}2}\left(2\ \text{years}\right) + ED_{2\text{-}6}\left(4\ \text{years}\right)}$$

$$SA_{res\text{-}c}\left(6365\ \text{cm}^2\right) = \frac{SA_{0\text{-}2}\left(6365\ \text{cm}^2\right) \times ED_{0\text{-}2}\left(2\ \text{years}\right) + SA_{2\text{-}6}\left(6365\ \text{cm}^2\right) \times ED_{2\text{-}6}\left(4\ \text{years}\right)}{ED_{0\text{-}2}\left(2\ \text{years}\right) + ED_{2\text{-}6}\left(4\ \text{years}\right)}$$

$$IRW_{res\text{-}c}\left(\frac{0.78\ \text{L}}{\text{day}}\right) = \frac{IRW_{0\text{-}2}\left(\frac{0.78\ \text{L}}{\text{day}}\right) \times ED_{0\text{-}2}\left(2\ \text{years}\right) + IRW_{2\text{-}6}\left(\frac{0.78\ \text{L}}{\text{day}}\right) \times ED_{2\text{-}6}\left(4\ \text{years}\right)}{ED_{0\text{-}2}\left(2\ \text{years}\right) + ED_{2\text{-}6}\left(4\ \text{years}\right)}$$

Adult

$$ED_{res\text{-}a}\,(20\text{ years}) = ED_{6\text{-}16}\,(10\text{ years}) + ED_{16\text{-}26}\,(10\text{ years})$$

$$BW_{res\text{-}a}\,(80\text{ kg}) = \frac{BW_{6\text{-}16}\,(80\text{ kg}) \times ED_{6\text{-}16}\,(10\text{ years}) + BW_{16\text{-}26}\,(80\text{ kg}) \times ED_{16\text{-}26}\,(10\text{ years})}{ED_{6\text{-}16}\,(10\text{ years}) + ED_{16\text{-}26}\,(10\text{ years})}$$

$$EV_{res\text{-}a}\left(\frac{1\text{ event}}{\text{day}}\right) = \frac{EV_{6\text{-}16}\left(\frac{1\text{ event}}{\text{day}}\right) \times ED_{6\text{-}16}\,(10\text{ years}) + EV_{16\text{-}26}\left(\frac{1\text{ event}}{\text{day}}\right) \times ED_{16\text{-}26}\,(10\text{ years})}{ED_{6\text{-}16}\,(10\text{ years}) + ED_{16\text{-}26}\,(10\text{ years})}$$

$$EF_{res\text{-}a}\left(\frac{350\text{ days}}{\text{year}}\right) = \frac{EF_{6\text{-}16}\left(\frac{350\text{ days}}{\text{year}}\right) \times ED_{6\text{-}16}\,(10\text{ years}) + EF_{16\text{-}26}\left(\frac{350\text{ days}}{\text{year}}\right) \times ED_{16\text{-}26}\,(10\text{ years})}{ED_{6\text{-}16}\,(10\text{ years}) + ED_{16\text{-}26}\,(10\text{ years})}$$

$$ET_{event\text{-}res\text{-}a}\left(\frac{0.71\text{ hours}}{\text{event}}\right) = \frac{ET_{event\,(6\text{-}16)}\left(\frac{0.71\text{ hours}}{\text{event}}\right) \times ED_{6\text{-}16}\,(10\text{ years}) + ET_{event\,(16\text{-}26)}\left(\frac{0.71\text{ hours}}{\text{event}}\right) \times ED_{16\text{-}26}\,(10\text{ years})}{ED_{6\text{-}16}\,(10\text{ years}) + ED_{16\text{-}26}\,(10\text{ years})}$$

$$ET_{res\text{-}a}\left(\frac{24\text{ hours}}{\text{day}}\right) = \frac{ET_{6\text{-}16}\left(\frac{24\text{ hours}}{\text{day}}\right) \times ED_{6\text{-}16}\,(10\text{ years}) + ET_{16\text{-}26}\left(\frac{24\text{ hours}}{\text{day}}\right) \times ED_{16\text{-}26}\,(10\text{ years})}{ED_{6\text{-}16}\,(10\text{ years}) + ED_{16\text{-}26}\,(10\text{ years})}$$

$$SA_{res\text{-}a}\left(19652\text{ cm}^2\right) = \frac{SA_{6\text{-}16}\left(19652\text{ cm}^2\right) \times ED_{6\text{-}16}\,(10\text{ years}) + SA_{16\text{-}26}\left(19652\text{ cm}^2\right) \times ED_{16\text{-}26}\,(10\text{ years})}{ED_{6\text{-}16}\,(10\text{ years}) + ED_{16\text{-}26}\,(10\text{ years})}$$

$$IRW_{res\text{-}a}\left(\frac{2.5\text{ L}}{\text{day}}\right) = \frac{IRW_{6\text{-}16}\left(\frac{2.5\text{ L}}{\text{day}}\right) \times ED_{6\text{-}16}\,(10\text{ years}) + IRW_{16\text{-}26}\left(\frac{2.5\text{ L}}{\text{day}}\right) \times ED_{16\text{-}26}\,(10\text{ years})}{ED_{6\text{-}16}\,(10\text{ years}) + ED_{16\text{-}26}\,(10\text{ years})}$$

Age-adjusted

$$ED_{res}\left(26\text{ years}\right) = ED_{0\text{-}2}\left(2\text{ years}\right) + ED_{2\text{-}6}\left(4\text{ years}\right) + ED_{6\text{-}16}\left(10\text{ years}\right) + ED_{16\text{-}26}\left(10\text{ years}\right)$$

$$EF_{res}\left(\frac{350\text{ days}}{\text{year}}\right) = \frac{\begin{gathered}EF_{0\text{-}2}\left(\frac{350\text{ days}}{\text{year}}\right)\times ED_{0\text{-}2}\left(2\text{ years}\right) + EF_{2\text{-}6}\left(\frac{350\text{ days}}{\text{year}}\right)\times ED_{2\text{-}6}\left(4\text{ years}\right) + \\ EF_{6\text{-}16}\left(\frac{350\text{ days}}{\text{year}}\right)\times ED_{6\text{-}16}\left(10\text{ years}\right) + EF_{16\text{-}26}\left(\frac{350\text{ days}}{\text{year}}\right)\times ED_{16\text{-}26}\left(10\text{ years}\right)\end{gathered}}{ED_{0\text{-}2}\left(2\text{ years}\right) + ED_{2\text{-}6}\left(4\text{ years}\right) + ED_{6\text{-}16}\left(10\text{ years}\right) + ED_{16\text{-}26}\left(10\text{ years}\right)}$$

$$ET_{res}\left(\frac{24\text{ hours}}{\text{day}}\right) = \frac{\begin{gathered}ET_{0\text{-}2}\left(\frac{24\text{ hours}}{\text{day}}\right)\times ED_{0\text{-}2}\left(2\text{ years}\right) + ET_{2\text{-}6}\left(\frac{24\text{ hours}}{\text{day}}\right)\times ED_{2\text{-}6}\left(4\text{ years}\right) + \\ ET_{6\text{-}16}\left(\frac{24\text{ hours}}{\text{day}}\right)\times ED_{6\text{-}16}\left(10\text{ years}\right) + ET_{16\text{-}26}\left(\frac{24\text{ hours}}{\text{day}}\right)\times ED_{16\text{-}26}\left(10\text{ years}\right)\end{gathered}}{ED_{0\text{-}2}\left(2\text{ years}\right) + ED_{2\text{-}6}\left(4\text{ years}\right) + ED_{6\text{-}16}\left(10\text{ years}\right) + ED_{16\text{-}26}\left(10\text{ years}\right)}$$

A1.1.3 Air

Noncarcinogenic

$$SL_{res\text{-}air\text{-}nc}\left(\mu g/m^3\right) = \frac{THQ\times AT_{res\text{-}a}\left(\frac{365\text{ days}}{\text{year}}\times ED_{res}\left(26\text{ years}\right)\right)\times\left(\frac{1000\ \mu g}{mg}\right)}{EF_{res}\left(\frac{350\text{ days}}{\text{year}}\right)\times ED_{res}\left(26\text{ years}\right)\times ET_{res}\left(\frac{24\text{ hours}}{\text{day}}\right)\times\left(\frac{1\text{ day}}{24\text{ hours}}\right)\times\frac{1}{RfC\left(mg/m^3\right)}}$$

Carcinogenic

$$SL_{res\text{-}air\text{-}ca}\left(\mu g/m^3\right) = \frac{TR\times AT_{res}\left(\frac{365\text{ days}}{\text{year}}\times LT\left(70\text{ years}\right)\right)}{EF_{res}\left(\frac{350\text{ days}}{\text{year}}\right)\times ED_{res}\left(26\text{ years}\right)\times ET_{res}\left(\frac{24\text{ hours}}{\text{day}}\right)\times\left(\frac{1\text{ day}}{24\text{ hours}}\right)\times IUR\left(\mu g/m^3\right)^{-1}}$$

Mutagenic

$$SL_{res\text{-}air\text{-}mu}\left(\mu g/m^3\right) = \frac{TR \times AT_{res}\left(\frac{365\ \text{days}}{\text{year}} \times LT\ (70\ \text{years})\right)}{IUR\left(\mu g/m^3\right)^{-1} \times \left(\frac{1\ \text{day}}{24\ \text{hours}}\right) \times \left(\begin{array}{l}\left(ED_{0\text{-}2}\ (2\ \text{years}) \times EF_{0\text{-}2}\left(\frac{350\ \text{days}}{\text{year}}\right) \times ET_{0\text{-}2}\left(\frac{24\ \text{hours}}{\text{day}}\right) \times 10\right) + \\ \left(ED_{2\text{-}6}\ (4\ \text{years}) \times EF_{2\text{-}6}\left(\frac{350\ \text{days}}{\text{year}}\right) \times ET_{2\text{-}6}\left(\frac{24\ \text{hours}}{\text{day}}\right) \times 3\right) + \\ \left(ED_{6\text{-}16}\ (10\ \text{years}) \times EF_{6\text{-}16}\left(\frac{350\ \text{days}}{\text{year}}\right) \times ET_{6\text{-}16}\left(\frac{24\ \text{hours}}{\text{day}}\right) \times 3\right) + \\ \left(ED_{16\text{-}26}\ (10\ \text{years}) \times EF_{16\text{-}26}\left(\frac{350\ \text{days}}{\text{year}}\right) \times ET_{16\text{-}26}\left(\frac{24\ \text{hours}}{\text{day}}\right) \times 1\right)\end{array}\right)}$$

Vinyl Chloride

$$SL_{res\text{-}air\text{-}ca\text{-}vinyl\ chloride}\left(\mu g/m^3\right) = \frac{TR}{IUR\left(\mu g/m^3\right)^{-1} + \left(\frac{IUR\left(\mu g/m^3\right)^{-1} \times EF_{res}\left(\frac{350\ \text{days}}{\text{year}}\right) \times ED_{res}\ (26\ \text{years}) \times ET_{res}\left(\frac{24\ \text{hours}}{\text{day}}\right) \times \left(\frac{1\ \text{day}}{24\ \text{hours}}\right)}{AT_{res}\left(\frac{365\ \text{days}}{\text{year}} \times LT\ (70\ \text{years})\right)}\right)}$$

Trichloroethylene

$$SL_{res\text{-}air\text{-}tce}\left(\mu g/m^3\right) = \frac{TR \times AT_{res}\left(\frac{365\ \text{days}}{\text{year}} \times LT\ (70\ \text{years})\right)}{IUR\left(\mu g/m^3\right)^{-1} \times \left(\frac{1\ \text{day}}{24\ \text{hours}}\right) \times \left(\begin{array}{l}\left(ED_{res}\ (26\ \text{years}) \times EF_{res}\left(\frac{350\ \text{days}}{\text{year}}\right) \times ET_{res}\left(\frac{24\ \text{hours}}{\text{day}}\right) \times CAF_i\ (0.756)\right) + \\ \left(\begin{array}{l}\left(ED_{0\text{-}2}\ (2\ \text{years}) \times EF_{0\text{-}2}\left(\frac{350\ \text{days}}{\text{year}}\right) \times ET_{0\text{-}2}\left(\frac{24\ \text{hours}}{\text{day}}\right) \times MAF_i\ (0.244) \times 10\right) + \\ \left(ED_{2\text{-}6}\ (4\ \text{years}) \times EF_{2\text{-}6}\left(\frac{350\ \text{days}}{\text{year}}\right) \times ET_{2\text{-}6}\left(\frac{24\ \text{hours}}{\text{day}}\right) \times MAF_i\ (0.244) \times 3\right) + \\ \left(ED_{6\text{-}16}\ (10\ \text{years}) \times EF_{6\text{-}16}\left(\frac{350\ \text{days}}{\text{year}}\right) \times ET_{6\text{-}16}\left(\frac{24\ \text{hours}}{\text{day}}\right) \times MAF_i\ (0.244) \times 3\right) + \\ \left(ED_{16\text{-}26}\ (10\ \text{years}) \times EF_{16\text{-}26}\left(\frac{350\ \text{days}}{\text{year}}\right) \times ET_{16\text{-}26}\left(\frac{24\ \text{hours}}{\text{day}}\right) \times MAF_i\ (0.244) \times 1\right)\end{array}\right)\end{array}\right)}$$

Refractory Ceramic Fibers

$$SL_{res\text{-}air\text{-}rcf}\left(\tfrac{f}{m^3}\right)=\frac{THQ\times AT_{res\text{-}a}\left(\frac{365\ days}{year}\times ED_{res}\,(26\ years)\right)}{EF_{res}\left(\frac{350\ days}{year}\right)\times ED_{res}\,(26\ years)\times ET_{res}\left(\frac{24\ hours}{day}\right)\times\left(\frac{1\ day}{24\ hours}\right)\times\frac{1}{RfC\left(\tfrac{f}{m^3}\right)}}$$

A1.1.4 Food

Noncarcinogenogenic

$$SL_{res\text{-}fsh\text{-}nc\text{-}ing}\,(mg/kg)=\frac{THQ\times AT_{res\text{-}a}\left(\frac{365\ days}{year}\times ED_{res}\,(26\ years)\right)\times BW_{res\text{-}a}\,(80\ kg)}{EF_{res\text{-}a}\left(\frac{350\ days}{year}\right)\times ED_{res}\,(26\ years)\times\frac{1}{RfD_o\left(\frac{mg}{kg\text{-}day}\right)}\times IRF_{res\text{-}a}\left(\frac{mg}{day}\right)\times\frac{10^{-6}kg}{1\,mg}}$$

Carcinogenic

$$SL_{res\text{-}fsh\text{-}ca\text{-}ing}\,(mg/kg)=\frac{TR\times AT_{res}\left(\frac{365\ days}{year}\times LT\,(70\ years)\right)\times BW_{res\text{-}a}\,(80\ kg)}{EF_{res}\left(\frac{350\ days}{year}\right)\times ED_{res}\,(26\ years)\times CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1}\times IRF_{res\text{-}a}\left(\frac{mg}{day}\right)\times\frac{10^{-6}kg}{1\ mg}}$$

A1.2 Industrial/Commercial

All Industrial/Commercial equations are for Composite Worker. See the RSL User's Guide (EPA, 2017e) for indoor and outdoor worker equations. As industrial workers are presumed to be adults, age-adjusted and mutagenic equations, as well as TCE/VC specific equations, do not apply to the industrial worker computations.

Virginia DEQ considers drinking water as the highest beneficial use for groundwater. The groundwater exposure pathway for the industrial study area is evaluated in the quantitative risk assessment module using residential tapwater exposure defaults and equations. See section A1.1 for exposure parameters and section A1.1.2 for RSL tapawater equations.

Groundwater VI is screened under the groundwater medium. Groundwater VI screening values are computed from contaminant concentrations in groundwater, **NOT** air. Refer to section A1.6 for groundwater VI equations. However, the quantitative risk assessment module does **NOT** calculate groundwater VI risk based on groundwater contaminant concentrations; air contaminant concentrations must be entered in µg/m3. Refer to VISL Calculator User's Guide for more details.

Table A1.2-1 Industrial Exposure Parameters

Symbol	Description	Value	Units	Source
AFw	Composite Worker Soil Adherence Factor	0.12	(mg/cm2)	EPA
AFw	Composite Worker Soil Adherence Factor	0.12	(mg/cm2)	EPA
ATw	Composite Worker Averaging Time	365	(days/yr)	EPA
ATw	Composite Worker Averaging Time: 365 x LT	25550	(days)	EPA
ATw-a	Composite Worker Averaging Time: 365 x EDw	9125	(days)	EPA
BWw	Composite Worker Body Weight	80	(kg)	EPA
EDw	Composite Worker Total Exposure Duration	25	(yrs)	EPA
EFw	Composite Worker Exposure Frequency	250	(days/yr)	EPA
ETw	Composite Worker Exposure Time	8	(hrs/day)	EPA
ETw-ai	Composite Worker Air Inhalation Exposure Time	8	(hrs/day)	EPA
ETw-si	Composite Worker Soil Inhalation Exposure Time	8	(hrs/day)	EPA
IRw	Composite Worker Soil Ingestion Rate	100	(mg/day)	EPA
SAw	Composite Worker Soil Surface Area	3527	(cm2/day)	EPA

A1.2.1 Soil

Noncarcinogenic

Ingestion

$$SL_{w\text{-soil-nc-ing}}(\text{mg/kg}) = \frac{THQ \times AT_{w\text{-a}}\left(\frac{365\ \text{days}}{\text{year}} \times ED_w\ (25\ \text{years})\right) \times BW_w\ (80\ \text{kg})}{EF_w\left(250\ \frac{\text{days}}{\text{year}}\right) \times ED_w\ (25\ \text{years}) \times \frac{RBA}{RfD_o\left(\frac{\text{mg}}{\text{kg-day}}\right)} \times IR_w\left(100\ \frac{\text{mg}}{\text{day}}\right) \times \left(\frac{10^{-6}\ \text{kg}}{1\ \text{mg}}\right)}$$

Dermal

$$SL_{w\text{-soil-nc-der}}(\text{mg/kg}) = \frac{THQ \times AT_{w\text{-a}}\left(\frac{365\ \text{days}}{\text{year}} \times ED_w\ (25\ \text{years})\right) \times BW_w\ (80\ \text{kg})}{EF_w\left(250\ \frac{\text{days}}{\text{year}}\right) \times ED_w\ (25\ \text{years}) \times \left(\frac{1}{RfD_o\left(\frac{\text{mg}}{\text{kg-day}}\right) \times GIABS}\right) \times SA_w\left(\frac{3527\ \text{cm}^2}{\text{day}}\right) \times AF_w\left(\frac{0.12\ \text{mg}}{\text{cm}^2}\right) \times ABS_d \times \left(\frac{10^{-6}\ \text{kg}}{1\ \text{mg}}\right)}$$

Inhalation

$$SL_{w\text{-}soil\text{-}nc\text{-}inh}\,(mg/kg) = \frac{THQ \times AT_{w\text{-}a}\left(\frac{365\ days}{year} \times ED_w\,(25\ years)\right)}{EF_w\left(250\ \frac{days}{year}\right) \times ED_w\,(25\ years) \times ET_w\left(\frac{8\ hours}{day}\right) \times \left(\frac{1\ day}{24\ hours}\right) \times \frac{1}{RfC\left(mg/m^3\right)} \times \left(\frac{1}{VF_s\left(\frac{m^3}{kg}\right)} + \frac{1}{PEF_w\left(\frac{m^3}{kg}\right)}\right)}$$

Total

$$SL_{w\text{-}soil\text{-}nc\text{-}tot}\,(mg/kg) = \frac{1}{\frac{1}{SL_{w\text{-}soil\text{-}nc\text{-}ing}} + \frac{1}{SL_{w\text{-}soil\text{-}nc\text{-}der}} + \frac{1}{SL_{w\text{-}soil\text{-}nc\text{-}inh}}}$$

Carcinogenic

Ingestion

$$SL_{w\text{-}soil\text{-}ca\text{-}ing}\,(mg/kg) = \frac{TR \times AT_w\left(\frac{365\ days}{year} \times LT\,(70\ years)\right) \times BW_w\,(80\ kg)}{EF_w\left(250\ \frac{days}{year}\right) \times ED_w\,(25\ years) \times CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1} \times RBA \times IR_w\left(100\ \frac{mg}{day}\right) \times \left(\frac{10^{-6}\ kg}{1\ mg}\right)}$$

Dermal

$$SL_{w\text{-}soil\text{-}ca\text{-}der}\,(mg/kg) = \frac{TR \times AT_w\left(\frac{365\ days}{year} \times LT\,(70\ years)\right) \times BW_w\,(80\ kg)}{EF_w\left(250\ \frac{days}{year}\right) \times ED_w\,(25\ years) \times \left(\frac{CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1}}{GIABS}\right) \times SA_w\left(\frac{3527\ cm^2}{day}\right) \times AF_w\left(\frac{0.12\ mg}{cm^2}\right) \times ABS_d \times \left(\frac{10^{-6}\ kg}{1\ mg}\right)}$$

Inhalation

$$SL_{w\text{-}soil\text{-}ca\text{-}inh}\,(mg/kg) = \frac{TR \times AT_w\left(\frac{365\ days}{year} \times LT\,(70\ years)\right)}{EF_w\left(250\ \frac{days}{year}\right) \times ED_w\,(25\ years) \times ET_w\left(\frac{8\ hours}{day}\right) \times \left(\frac{1\ day}{24\ hours}\right) \times IUR\left(\mu g/m^3\right)^{-1} \times \left(\frac{1000\ \mu g}{mg}\right) \times \left(\frac{1}{VF_s\left(\frac{m^3}{kg}\right)} + \frac{1}{PEF_w\left(\frac{m^3}{kg}\right)}\right)}$$

Total

$$SL_{w\text{-}soil\text{-}ca\text{-}tot}\,(mg/kg) = \frac{1}{\frac{1}{SL_{w\text{-}soil\text{-}ca\text{-}ing}} + \frac{1}{SL_{w\text{-}soil\text{-}ca\text{-}der}} + \frac{1}{SL_{w\text{-}soil\text{-}ca\text{-}inh}}}$$

A1.2.2 Air

Noncarcinogenic

$$SL_{w\text{-}air\text{-}nc}\left(\mu g/m^3\right)=\frac{THQ\times AT_w\left(\frac{365\ days}{year}\times ED_w\ (25\ years)\right)\times\left(\frac{1000\ \mu g}{mg}\right)}{EF_w\left(\frac{250\ days}{year}\right)\times ED_w\ (25\ years)\times ET_w\left(\frac{8\ hours}{24\ hours}\right)\times\frac{1}{RfC\left(\frac{mg}{m^3}\right)}}$$

Carcinogenic

$$SL_{w\text{-}air\text{-}ca}\left(\mu g/m^3\right)=\frac{TR\times AT_w\left(\frac{365\ days}{year}\times LT\ (70\ years)\right)}{EF_w\left(\frac{250\ days}{year}\right)\times ED_w\ (25\ years)\times ET_w\left(\frac{8\ hours}{24\ hours}\right)\times IUR\left(\frac{\mu g}{m^3}\right)^{-1}}$$

Refractory Ceramic Fibers

$$SL_{w\text{-}air\text{-}rcf}\left(\frac{f}{m^3}\right)=\frac{THQ\times AT_w\left(\frac{365\ days}{year}\times ED_w\ (25\ years)\right)}{EF_w\left(\frac{250\ days}{year}\right)\times ED_w\ (25\ years)\times ET_w\left(\frac{8\ hours}{day}\right)\times\left(\frac{1\ day}{24\ hours}\right)\times\frac{1}{RfC\left(\frac{f}{m^3}\right)}}$$

A1.3 Construction

The construction worker scenario described in the Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites (EPA 2002) is limited to an exposure duration of 1 year and is therefore subchronic. Subchronic RfDo and RfCi values are obtained from the RSL Calculator Metadata and updated annually. Where available, subchronic toxicity values are used to calculate noncancer hazard values. If no subchronic value is provided, VURAM calculations default to the chronic toxicity values for construction worker. As construction workers are presumed to be adults, age-adjusted and mutagenic equations, as well as TCE/VC specific equations, do not apply to the construction worker computations.

Soil screening values for the construction worker scenario are not provided in VURAM. For quantitative risk assessment the EPA Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites (EPA, 2002) provides a detailed method for calculating PEF for the two construction worker scenarios, (1) standard vehicle traffic, and (2) other than standard vehicle traffic (grading, dozing, tilling, and excavation). However, default values are not provided for many of the input parameters, and these parameters are difficult to estimate due to the wide variety of different potential construction scenarios. Calculation of a PEF for a construction worker is significantly more complex than for residential and composite worker scenarios, which are modeled on the generation of particulates due to wind erosion. These values may not be sufficiently conservative for a construction worker scenario due to the increased potential for particulates during construction activities. Therefore, the PEF value for a construction worker was calculated by using the wind-driven PEF equation and applying the dispersion constants for Philadelphia provided in Appendix D, Exhibit D-2, of the supplemental guidance document

(EPA, 2002). VURAM calculations for soil rely on the standard vehicle traffic scenario and unique subchronic PEF and VF calculations included in the supporting equations of this appendix.

Construction screening and quantitative risk assessment values for groundwater, groundwater-VI, and soil gas are based on the Virginia DEQ Construction Worker Trench Model developed in appendix A2.0.

Table A1.3-1 Construction Exposure Parameters

Symbol	Description	Value	Units	Source
A	Construction Worker Soil Inhalation Dispersion Constant - Virginia DEQ	14.0111	(unitless)	DEQ
A	Construction Worker Soil Inhalation Dispersion Constant - Virginia DEQ	14.0111	(unitless)	DEQ
AFcw	Construction Worker Soil Adherence Factor	0.3	(mg/cm2)	EPA
As	Areal extent of the site or contamination	0.5	(acres)	EPA
ATcw	Construction Worker Averaging Time: 365 x LT	25550	(days)	EPA
ATcw	Construction Worker Averaging Time	365	(days/yr)	EPA
ATcw-a	Construction Worker Averaging Time: EWcw x 7 x EDcw	350	(days)	EPA
B	Construction Worker Soil Inhalation Dispersion Constant - Virginia DEQ	19.6154	(unitless)	DEQ
BWcw	Construction Worker Body Weight	80	(kg)	EPA
C	Construction Worker Soil Inhalation Dispersion Constant - Virginia DEQ	225.3397	(unitless)	DEQ
DWcw	Construction Worker Days Worked	5	(days/week)	EPA
EDcw	Construction Worker Exposure Duration	1	(yrs)	EPA
EFcw	Construction Worker Exposure Frequency	250	(days/yrs)	EPA
EFcw-a	Construction Worker Air Exposure Frequency	250	(days/yr)	EPA
EFcw-s	Construction Worker Soil Exposure Frequency	250	(days/yr)	EPA
EFcw-vrp	Construction Worker Soil Exposure Frequency - VRP ONLY - Virginia DEQ	125	(days/yr)	DEQ

Symbol	Description	Value	Units	Source
ETcw	Construction Worker Exposure Time	8	(hrs/day)	EPA
ETcw-s	Construction Worker Soil Exposure Time	8	(hrs/day)	EPA
EWcw	Construction Worker Weeks Worked	50	(weeks/yr)	EPA
F(x)	Function Dependent on 0.886 × (Ut/Um)	0.194	(unitless)	EPA
Fd	Dispersion Correction Factor	0.185	(unitless)	EPA
IRcw	Construction Worker Soil Ingestion Rate	330	(mg/day)	EPA
n	Total soil porosity: 1-(ρb/ρs)	0.433962	(unitless)	DEQ
PEFsc	Particulate Emission Factor Subchronic - Virginia DEQ calculated	1.27E+09	(m3/kg)	DEQ
Q/C	Inverse of the ratio of the 1-h geometric mean concentration to the emission flux along a straight road segment bisecting a square site - Virginia DEQ calculated	87.36898	(g/m2-s per kg/m)	DEQ
SAcw	Construction Worker Surface Area	3527	(cm2/day)	EPA
Tc	Total time over which construction occurs: EDcw*EWcw*7days/wk*24hrs/day*3600s/hr	30240000	(s)	DEQ
Um	Mean Annual Wind Speed	4.69	(m/s)	EPA
Ut	Equivalent Threshold Value of Wind Speed at 7m	11.32	(m/s)	EPA
V	V Fraction of Vegetative Cover	0.5	(unitless)	EPA
Θa	Air filled soil porosity: n-Θw	0.133962	(unitless)	DEQ
Θw	Water filled soil porosity	0.3	(unitless)	EPA
ρb	Dry soil bulk density	1.5	(kg/L)	EPA
ρs	Soil particle density	2.65	(kg/L)	EPA

A1.3.1 Soil

Noncarcinogenic

Ingestion

$$SL_{cw\text{-}soil\text{-}nc\text{-}ing}\,(mg/kg) = \frac{THQ \times AT_{cw\text{-}a}\left(EW_{cw}\,\frac{50\text{ weeks}}{\text{year}} \times \frac{7\text{ days}}{\text{week}} \times ED_{cw}\,(1\text{ year})\right) \times BW_{cw}\,(80\text{ kg})}{EF_{cw}\left(EW_{cw}\,\frac{50\text{ weeks}}{\text{year}} \times DW_{cw}\,\frac{5\text{ days}}{\text{week}}\right) \times ED_{cw}\,(1\text{ year}) \times \frac{RBA}{RfD_o\left(\frac{mg}{kg\text{-}day}\right)} \times IR_{cw}\left(330\,\frac{mg}{day}\right) \times \left(\frac{10^{-6}\text{ kg}}{1\text{ mg}}\right)}$$

Dermal

$$SL_{cw\text{-}soil\text{-}nc\text{-}der}\,(mg/kg) = \frac{THQ \times AT_{cw\text{-}a}\left(EW_{cw}\,\frac{50\text{ weeks}}{\text{year}} \times \frac{7\text{ days}}{\text{week}} \times ED_{cw}\,(1\text{ year})\right) \times BW_{cw}\,(80\text{ kg})}{EF_{cw}\left(EW_{cw}\,\frac{50\text{ weeks}}{\text{year}} \times DW_{cw}\,\frac{5\text{ days}}{\text{week}}\right) \times ED_{cw}\,(1\text{ year}) \times \left(\frac{1}{RfD_o\left(\frac{mg}{kg\text{-}day}\right) \times GIABS}\right) \times SA_{cw}\left(\frac{3527\text{ cm}^2}{day}\right) \times AF_{cw}\left(\frac{0.3\text{ mg}}{\text{cm}^2}\right) \times ABS_d \times \left(\frac{10^{-6}\text{ kg}}{1\text{ mg}}\right)}$$

Inhalation

$$SL_{cw\text{-}soil\text{-}nc\text{-}inh}\,(mg/kg) = \frac{THQ \times AT_{cw\text{-}a}\left(EW_{cw}\,\frac{50\text{ weeks}}{\text{year}} \times \frac{7\text{ days}}{\text{week}} \times ED_{cw}\,(1\text{ year})\right)}{EF_{cw}\left(EW_{cw}\,\frac{50\text{ weeks}}{\text{year}} \times DW_{cw}\,\frac{5\text{ days}}{\text{week}}\right) \times ED_{cw}\,(1\text{ year}) \times ET_{cw}\left(\frac{8\text{ hours}}{day}\right) \times \left(\frac{1\text{ day}}{24\text{ hours}}\right) \times \frac{1}{RfC\left(^{mg}/_{m^3}\right)} \times \left(\frac{1}{VF_{sc}\left(\frac{m^3}{kg}\right)} + \frac{1}{PEF_{sc}\left(\frac{m^3}{kg}\right)}\right)}$$

Carcinogenic

Ingestion

$$SL_{cw\text{-}soil\text{-}ca\text{-}ing}\,(mg/kg) = \frac{TR \times AT_{cw}\left(\frac{365\text{ days}}{\text{year}} \times LT\,(70\text{ years})\right) \times BW_{cw}\,(80\text{ kg})}{EF_{cw}\left(EW_{cw}\,\frac{50\text{ weeks}}{\text{year}} \times DW_{cw}\,\frac{5\text{ days}}{\text{week}}\right) \times ED_{cw}\,(1\text{ year}) \times CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1} \times RBA \times IR_{cw}\left(330\,\frac{mg}{day}\right) \times \left(\frac{10^{-6}\text{ kg}}{1\text{ mg}}\right)}$$

Dermal

$$SL_{cw\text{-}soil\text{-}ca\text{-}der}\,(mg/kg) = \frac{TR \times AT_{cw}\left(\frac{365\text{ days}}{\text{year}} \times LT\,(70\text{ years})\right) \times BW_{cw}\,(80\text{ kg})}{EF_{cw}\left(EW_{cw}\,\frac{50\text{ weeks}}{\text{year}} \times DW_{cw}\,\frac{5\text{ days}}{\text{week}}\right) \times ED_{cw}\,(1\text{ year}) \times \left(\frac{CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1}}{GIABS}\right) \times SA_{cw}\left(\frac{3527\text{ cm}^2}{day}\right) \times AF_{cw}\left(\frac{0.3\text{ mg}}{\text{cm}^2}\right) \times ABS_d \times \left(\frac{10^{-6}\text{ kg}}{1\text{ mg}}\right)}$$

Inhalation

$$SL_{cw\text{-}soil\text{-}ca\text{-}inh}\,(mg/kg) = \frac{TR \times AT_{cw}\left(\frac{365\text{ days}}{\text{year}} \times LT\,(70\text{ years})\right)}{EF_{cw}\left(EW_{cw}\,\frac{50\text{ weeks}}{\text{year}} \times DW_{cw}\,\frac{5\text{ days}}{\text{week}}\right) \times ED_{cw}\,(1\text{ year}) \times ET_{cw}\left(\frac{8\text{ hours}}{day}\right) \times \left(\frac{1\text{ day}}{24\text{ hours}}\right) \times IUR\left(^{\mu g}/_{m^3}\right)^{-1} \times \left(\frac{1000\,\mu g}{mg}\right) \times \left(\frac{1}{VF_{sc}\left(\frac{m^3}{kg}\right)} + \frac{1}{PEF_{sc}\left(\frac{m^3}{kg}\right)}\right)}$$

Supporting Equations

Wind-driven PEFsc

$$PEF\left(\frac{m^3_{air}}{kg_{soil}}\right) = \frac{Q}{C_{wind}}\left(\frac{\left(\frac{g}{m^2 \cdot s}\right)}{\left(\frac{kg}{m^3}\right)}\right) \times \frac{3{,}600\left(\frac{s}{hour}\right)}{0.036 \times (1 - V) \times \left(\frac{U_m\left(\frac{m}{s}\right)}{U_t\left(\frac{m}{s}\right)}\right)^3 \times F(x)}$$

where:

$$\frac{Q}{C_{wind}} = A \times \exp\left[\frac{\left(\ln A_s\,(acre) - B\right)^2}{C}\right]$$

and:

$$\text{if } x < 2,\ F(x) = 1.91207 - 0.0278085\ x + 0.48113\ x^2 - 1.09871\ x^3 + 0.335341\ x^4$$

$$\text{if } x \geq 2,\ F(x) = 0.18\left(8x^3 + 12x\right)e^{\left(-x^2\right)}$$

where:

$$x = 0.886 \times \left(\frac{U_t}{U_m}\right)$$

Volatilization Factor Subchronic (VFsc)

$$VF_{ulim\text{-}sc}\left(\frac{m^3_{air}}{kg_{soil}}\right) = \frac{Q}{C_{sa}}\left(\frac{\left(\frac{g}{m^2\text{-}s}\right)}{\left(\frac{kg}{m^3}\right)}\right) \times \frac{1}{F_D} \times \left[\frac{\left(3.14 \times D_A\left(\frac{cm^2}{s}\right) \times T_c(s)\right)^{1/2}}{2 \times \rho_b\left(\frac{1.5\,g}{cm^3}\right) \times D_A\left(\frac{cm^2}{s}\right)}\right] \times 10^{-4}\left(\frac{m^2}{cm^2}\right)$$

where:

$$\frac{Q}{C_{sa}}\left(\frac{\left(\frac{g}{m^2\text{-}s}\right)}{\left(\frac{kg}{m^3}\right)}\right) = A \times \exp\left[\frac{\left(\ln A_s(acre) - B\right)^2}{C}\right]$$

$$D_A\left(\frac{cm^2}{s}\right) = \frac{\left(\theta_a\left(\frac{L_{air}}{L_{soil}}\right)^{10/3} \times D_{ia}\left(\frac{cm^2}{s}\right) \times H' + \theta_w\left(\frac{0.15\,L_{water}}{L_{soil}}\right)^{10/3} \times D_{iw}\left(\frac{cm^2}{s}\right)\right) \Big/ n^2\left(\frac{L_{pore}}{L_{soil}}\right)}{\rho_b\left(\frac{1.5g}{cm^3}\right) \times K_d\left(\frac{cm^3}{g}\right) + \theta_w\left(\frac{0.15\,L_{water}}{L_{soil}}\right) + \theta_a\left(\frac{L_{air}}{L_{soil}}\right) \times H'}$$

$$\theta_a\left(\frac{L_{air}}{L_{soil}}\right) = n\left(\frac{L_{pore}}{L_{soil}}\right) - \theta_w\left(\frac{0.15\,L_{water}}{L_{soil}}\right) \text{and } n\left(\frac{L_{pore}}{L_{soil}}\right) = 1 - \left(\rho_b\left(\frac{1.5\,g}{cm^3}\right) \Big/ \rho_s\left(\frac{2.65\,g}{cm^3}\right)\right)$$

$$K_d\left(\frac{cm^3}{g}\right) = f_{oc}\left(\frac{0.006\,g}{g}\right) \times K_{oc}\left(\frac{cm^3}{g}\right) \text{ only for organics.}$$

$$T_c\ (30240000\ s) = ED_{cw}\ (1\ year) \times EW_{cw}\left(\frac{50\ weeks}{year}\right) \times \left(\frac{7\ days}{week}\right) \times \left(\frac{24\ hours}{day}\right) \times \left(\frac{3600\ s}{hour}\right)$$

$$F_D\ (0.18584) = 0.1852 + \left(5.3537 / t_c\right) + \left(-9.6318 / t_c^{\,2}\right)$$

$$t_c\ (8400\ hours) = ED_{cw}\ (1\ year) \times EW_{cw}\left(\frac{50\ weeks}{year}\right) \times \left(\frac{7\ days}{week}\right) \times \left(\frac{24\ hours}{day}\right)$$

A1.4 Recreator

The equations and parameters in this section are for quantitative risk assessment **ONLY** and do **NOT** apply to computing screening values for sediment or surface water. Recreator equations and parameters for soil are also applicable to recreator soil and sediment and to residential sediment. However, for sediment an adherence factor (AF) based on 2002 Soil Screening Guidance is used instead of the AF for soil. Surface water equations are applicable to quantitative hazard/risk calculations for both the recreator and the residential study area. Apply trespasser exposure defaults to the recreator soil/sediment and surface water equations to compute trespasser hazard/risk levels for the trespasser study area.

Symbol	Description	Value	Units	Source
AF0-02	Soil Adherence Factor - age segment 0-2	0.2	(mg/cm2)	EPA
AF02-06	Soil Adherence Factor - age segment 2-6	0.2	(mg/cm2)	EPA
AF06-16	Soil Adherence Factor - age segment 6-16	0.07	(mg/cm2)	EPA
AF16-26	Soil Adherence Factor - age segment 16-26	0.07	(mg/cm2)	EPA
AFrec-a	Recreator Soil Adherence Factor - adult	0.07	(mg/cm2)	EPA
AFrec-c	Recreator Soil Adherence Factor - child	0.2	(mg/cm2)	EPA
AFrec-sed-a	Recreator Sediment Adherence Factor - adult - Virginia DEQ	0.2	(mg/cm2)	DEQ
AFrec-sed-c	Recreator Sediment Adherence Factor - child - Virginia DEQ	0.3	(mg/cm2)	DEQ
AFsed0-02	Recreator/Trepasser Sediment Adherence Factor - age segment 0-2 - Virginia DEQ	0.3	(mg/cm2)	DEQ
AFsed02-06	Recreator/Trepasser Sediment Adherence Factor - age segment 2-6 - Virginia DEQ	0.3	(mg/cm2)	DEQ
AFsed06-16	Recreator/Trepasser Sediment Adherence Factor - age segment 6-16 - Virginia DEQ	0.2	(mg/cm2)	DEQ
AFsed16-26	Recreator/Trepasser Sediment Adherence Factor - age segment 16-26 - Virginia DEQ	0.2	(mg/cm2)	DEQ
ATrec	Recreator Averaging Time: 365 x LT	25550	(days)	EPA
ATrec	Recreator Averaging Time	365	(days/yr)	EPA
ATrec-a	Recreator Averaging Time - adult: 365 x EDrec-a	7300	(days)	EPA
ATrec-c	Recreator Averaging Time - child: 365 x EDrec-c	2190	(days)	EPA
BW0-02	Body Weight - age segment 0-2	15	(kg)	EPA
BW02-06	Body Weight - age segment 2-6	15	(kg)	EPA
BW06-16	Body Weight - age segment 6-16	80	(kg)	EPA
BW16-26	Body Weight - age segment 16-26	80	(kg)	EPA
BWrec-a	Recreator Body Weight - adult	80	(kg)	EPA

Symbol	Description	Value	Units	Source
BWrec-c	Recreator Body Weight - child	15	(kg)	EPA
DFSMrec-adj	Recreator Soil Mutagenic Dermal Contact Factor - age adjusted - Virginia DEQ calculated using age-segment values	238602	(mg/kg)	DEQ
DFSMrec-sed-adj	Recreator Sediment Mutagenic Dermal Contact Factor - age adjusted - Virginia DEQ calculated using age-segment values	413774.4	(mg/kg)	DEQ
DFSrec-adj	Recreator Soil Dermal Contact Factor - age adjusted - Virginia DEQ calculated using age-segment values	57603	(mg/kg)	DEQ
DFSrec-sed-adj	Recreator Sediment Dermal Contact Factor - age adjusted - Virginia DEQ calculated using age-segment values	114340.2	(mg/kg)	DEQ
DFWMrec-adj	Recreator Surface Water Mutagenic Dermal Contact Factor - age adjusted - Virginia DEQ calculated using age-segment values	4563910	(cm2-event/kg)	DEQ
DFWrec-adj	Recreator Surface Water Dermal Contact Factor - age adjusted - Virginia DEQ calculated using age-segment values	1454505	(cm2-event/kg)	DEQ
ED0-02	Exposure Duration - age segment 0-2	2	(yrs)	EPA
ED02-06	Exposure Duration - age segment 2-6	4	(yrs)	EPA
ED06-16	Exposure Duration -age segment 6-16	10	(yrs)	EPA
ED16-26	Exposure Duration -age segment 16-26	10	(yrs)	EPA
EDrec	Recreator Exposure Duration	26	(yrs)	EPA
EDrec-a	Recreator Exposure Duration - adult	20	(yrs)	EPA
EDrec-c	Recreator Exposure Duration - child	6	(yrs)	EPA
EFrec	Recreator Exposure Frequency - Virginia DEQ	195	(days/yr)	DEQ
EFrec0-02	Recreator/Trepasser Exposure Frequency - age segment 0-2 - Virginia DEQ	195	(days/yr)	DEQ
EFrec02-06	Recreator/Trepasser Exposure Frequency - age segment 2-6 - Virginia DEQ	195	(days/yr)	DEQ

Symbol	Description	Value	Units	Source
EFrec06-16	Recreator/Trepasser Exposure Frequency - age segment 6-16 - Virginia DEQ	195	(days/yr)	DEQ
EFrec16-26	Recreator/Trepasser Exposure Frequency - age segment 16-26 - Virginia DEQ	195	(days/yr)	DEQ
EFrec-a	Recreator Exposure Frequency - adult - Virginia DEQ	195	(days/yr)	DEQ
EFrec-c	Recreator Exposure Frequency - child - Virginia DEQ	195	(days/yr)	DEQ
ETevent-rec/trs(0-02)	Recreator/Trespasser Exposure Time - age segment 0-2 - Virginia DEQ	2	(hrs/event)	DEQ
ETevent-rec/trs(02-06)	Recreator/Trespasser Exposure Time - age segment 2-6 - Virginia DEQ	2	(hrs/event)	DEQ
ETevent-rec/trs(06-16)	Recreator/Trespasser Exposure Time - age segment 6-16 - Virginia DEQ	2	(hrs/event)	DEQ
ETevent-rec/trs(16-26)	Recreator/Trespasser Exposure Time - age segment 16-26 - Virginia DEQ	2	(hrs/event)	DEQ
ETevent-rec-a	Recreator Surface Water Exposure Time - adult - Virginia DEQ	2	(hrs/event)	DEQ
ETevent-rec-adj	Recreator Exposure Time - age adjusted - Virginia DEQ calculated using age-segment values	2	(hrs/event)	DEQ
ETevent-rec-c	Recreator Surface Water Exposure Time - child - Virginia DEQ	2	(hrs/event)	DEQ
ETevent-rec-madj	Recreator Exposure Time - mutagen age adjusted - Virginia DEQ calculated using age-segment values	2	(hrs/event)	DEQ
ETrec	Recreator Soil Exposure Time - Virginia DEQ	2	(hrs/day)	DEQ
ETrec/trs0-02	Recreator/Trespasser Exposure Time - age segment 0-2 - Virginia DEQ	2	(hrs/day)	DEQ

Symbol	Description	Value	Units	Source
ETrec/trs02-06	Recreator/Trespasser Exposure Time - age segment 2-6 - Virginia DEQ	2	(hrs/day)	DEQ
ETrec/trs06-16	Recreator/Trespasser Exposure Time - age segment 6-16 - Virginia DEQ	2	(hrs/day)	DEQ
ETrec/trs16-26	Recreator/Trespasser Exposure Time - age segment 16-26 - Virginia DEQ	2	(hrs/day)	DEQ
ETrec-a	Recreator Exposure Time - adult - Virginia DEQ	2	(hrs/day)	DEQ
ETrec-c	Recreator Exposure Time - child - Virginia DEQ	2	(hrs/day)	DEQ
ETrec-sed	Recreator Sediment Exposure Time - Virginia DEQ	2	(hrs/day)	DEQ
EV0-02	Events - age segment 0-2	1	(events/day)	DEQ
EV02-06	Events - age segment 2-6	1	(events/day)	DEQ
EV06-16	Events - age segment 6-16	1	(events/day)	DEQ
EV16-26	Events - age segment 16-26	1	(events/day)	DEQ
EVrec-a	Recreator Events - adult - Virginia DEQ	1	(events/day)	DEQ
EVrec-c	Recreator Events - child - Virginia DEQ	1	(events/day)	DEQ
IFMrec-sed-adj	Recreator Mutagenic Sediment Ingestion Rate - age adjusted - Virginia DEQ calculated using age-segment values	92950	(mg/kg)	DEQ
IFrec-sed-adj	Recreator Sediment Ingestion Rate - age adjusted - Virginia DEQ calculated using age-segment values	20475	(mg/kg)	DEQ
IFSMrec-adj	Recreator Mutagenic Soil Ingestion Rate - age adjusted - Virginia DEQ calculated using age-segment values	92950	(mg/kg)	DEQ
IFSrec-adj	Recreator Soil Ingestion Rate - age adjusted - Virginia DEQ calculated using age-segment values	20475	(mg/kg)	DEQ
IFWMrec-adj	Recreator Mutagenic Surface Water Ingestion Rate - age adjusted - Virginia DEQ calculated using age-segment values	122.7769	(L/kg)	DEQ

Symbol	Description	Value	Units	Source
IFWrec-adj	Recreator Surface Water Ingestion Rate - age adjusted - Virginia DEQ calculated using age-segment values	29.445	(L/kg)	DEQ
INHMrec-s-adj	Recreator Soil Inhalation Exposure Duration Mutagen - age adjusted - Virginia DEQ calculated using age-segment values	1170	(days)	DEQ
INHMrec-sed-adj	Recreator Sediment Inhalation Exposure Duration Mutagen - age adjusted - Virginia DEQ calculated using age-segment values	1170	(days)	DEQ
IRS0-02	Soil/Sediment Ingestion Rate - age segment 0-2	200	(mg/day)	EPA
IRS02-06	Soil/Sediment Ingestion Rate - age segment 2-6	200	(mg/day)	EPA
IRS06-16	Soil/Sediment Ingestion Rate - age segment 6-16	100	(mg/day)	EPA
IRS16-26	Soil/Sediment Ingestion Rate - age segment 16-26	100	(mg/day)	EPA
IRSrec-a	Recreator Soil Ingestion Rate - adult	100	(mg/day)	EPA
IRSrec-c	Recreator Soil Ingestion Rate - child	200	(mg/day)	EPA
IRSrec-sed-a	Recreator Sediment Ingestion Rate - adult	100	(mg/day)	EPA
IRSrec-sed-c	Recreator Sediment Ingestion Rate - child	200	(mg/day)	EPA
IRW0-02	Surface Water Ingestion Rate - age segment 0-2	0.12	(L/hr)	EPA
IRW02-06	Surface Water Ingestion Rate - age segment 2-6	0.12	(L/hr)	EPA
IRW06-16	Surface Water Ingestion Rate - age segment 6-16	0.124	(L/hr)	EPA
IRW16-26	Surface Water Ingestion Rate - age segment 16-26	0.0985	(L/hr)	EPA
IRWrec-a	Recreator Surface Water Ingestion Rate - adult	0.11	(L/hr)	EPA
IRWrec-c	Recreator Surface Water Ingestion Rate - child	0.12	(L/hr)	EPA
SArec-a	Recreator Surface Water Surface Area - adult	19652	(cm2)	EPA
SArec-a	Recreator Soil Surface Area - adult	6032	(cm2/day)	EPA

Symbol	Description	Value	Units	Source
SArec-c	Recreator Surface Water Surface Area - child	6365	(cm2)	EPA
SArec-c	Recreator Soil Surface Area - child	2373	(cm2/day)	EPA
SArec-sed-a	Recreator Sediment Surface Area - adult	6032	(cm2/day)	EPA
SArec-sed-c	Recreator Sediment Surface Area - child	2373	(cm2/day)	EPA
SAs0-02	Surface Area Soil/Sediment - age segment 0-2	2373	(cm2/day)	EPA
SAs02-06	Surface Area Soil/Sediment - age segment 2-6	2373	(cm2/day)	EPA
SAs06-16	Surface Area Soil/Sediment - age segment 6-16	6032	(cm2/day)	EPA
SAs16-26	Surface Area Soil/Sediment - age segment 16-26	6032	(cm2/day)	EPA
SAw0-02	Surface Area Water - age segment 0-2	6365	(cm2)	EPA
SAw02-06	Surface Area Water - age segment 2-6	6365	(cm2)	EPA
SAw06-16	Surface Area Water - age segment 6- 16	19652	(cm2)	EPA
SAw16-26	Surface Area Water - age segment 16- 26	19652	(cm2)	EPA

A1.4.1 Soil/Sediment

Noncarcinogenic Child

Ingestion

$$SL_{rec\text{-}soil\text{-}nc\text{-}ing\text{-}c}\left(mg/kg\right) = \frac{THQ \times AT_{rec\text{-}c}\left(\frac{365\ days}{year} \times ED_{rec\text{-}c}\left(6\ years\right)\right) \times BW_{rec\text{-}c}\left(15\ kg\right)}{EF_{rec\text{-}c}\left(\frac{days}{year}\right) \times ED_{rec\text{-}c}\left(6\ years\right) \times \frac{RBA}{RfD_o\left(\frac{mg}{kg\text{-}day}\right)} \times IRS_{rec\text{-}c}\left(\frac{200\ mg}{day}\right) \times \frac{10^{-6}kg}{1\,mg}}$$

Dermal

$$SL_{rec\text{-}soil\text{-}nc\text{-}der\text{-}c}\left(mg/kg\right) = \frac{THQ \times AT_{rec\text{-}c}\left(\frac{365\ days}{year} \times ED_{rec\text{-}c}\left(6\ years\right)\right) \times BW_{rec\text{-}c}\left(15\ kg\right)}{EF_{rec\text{-}c}\left(\frac{days}{year}\right) \times ED_{rec\text{-}c}\left(6\ years\right) \times \frac{1}{\left(RfD_o\left(\frac{mg}{kg\text{-}day}\right) \times GIABS\right)} \times SA_{rec\text{-}c}\left(\frac{2373\ cm^2}{day}\right) \times AF_{rec\text{-}c}\left(\frac{0.2\ mg}{cm^2}\right) \times ABS_d \times \frac{10^{-6}kg}{1\,mg}}$$

Inhalation

$$SL_{rec\text{-}soil\text{-}nc\text{-}inh\text{-}c}\,(mg/kg) = \frac{THQ \times AT_{rec\text{-}c}\left(\frac{365\ days}{year} \times ED_{rec\text{-}c}\,(6\ years)\right)}{EF_{rec\text{-}c}\left(\frac{days}{year}\right) \times ED_{rec\text{-}c}\,(6\ years) \times ET_{rec\text{-}c}\left(\frac{hours}{day}\right) \times \left(\frac{1\ day}{24\ hours}\right) \times \frac{1}{RfC\left(\frac{mg}{m^3}\right)} \times \left(\frac{1}{VF_s\left(\frac{m^3}{kg}\right)} + \frac{1}{PEF_w\left(\frac{m^3}{kg}\right)}\right)}$$

<u>**Noncarcinogenic Adult**</u>

Ingestion

$$SL_{rec\text{-}soil\text{-}nc\text{-}ing\text{-}a}\,(mg/kg) = \frac{THQ \times AT_{rec\text{-}a}\left(\frac{365\ days}{year} \times ED_{rec\text{-}a}\,(20\ years)\right) \times BW_{rec\text{-}a}\,(80\ kg)}{EF_{rec\text{-}a}\left(\frac{days}{year}\right) \times ED_{rec\text{-}a}\,(20\ years) \times \frac{RBA}{RfD_o\left(\frac{mg}{kg\text{-}day}\right)} \times IRS_{rec\text{-}a}\left(\frac{100\ mg}{day}\right) \times \frac{10^{-6}kg}{1mg}}$$

Dermal

$$SL_{rec\text{-}soil\text{-}nc\text{-}der\text{-}a}\,(mg/kg) = \frac{THQ \times AT_{rec\text{-}a}\left(\frac{365\ days}{year} \times ED_{rec\text{-}a}\,(20\ years)\right) \times BW_{rec\text{-}a}\,(80\ kg)}{EF_{rec\text{-}a}\left(\frac{days}{year}\right) \times ED_{rec\text{-}a}\,(20\ years) \times \frac{1}{\left(RfD_o\left(\frac{mg}{kg\text{-}day}\right) \times GIABS\right)} \times SA_{rec\text{-}a}\left(\frac{6032\ cm^2}{day}\right) \times AF_{rec\text{-}a}\left(\frac{0.07\ mg}{cm^2}\right) \times ABS_d \times \frac{10^{-6}kg}{1mg}}$$

Inhalation

$$SL_{rec\text{-}soil\text{-}nc\text{-}inh\text{-}a}\,(mg/kg) = \frac{THQ \times AT_{rec\text{-}a}\left(\frac{365\ days}{year} \times ED_{rec\text{-}a}\,(20\ years)\right)}{EF_{rec\text{-}a}\left(\frac{days}{year}\right) \times ED_{rec\text{-}a}\,(20\ years) \times ET_{rec\text{-}a}\left(\frac{hours}{day}\right) \times \left(\frac{1\ day}{24\ hours}\right) \times \frac{1}{RfC\left(\frac{mg}{m^3}\right)} \times \left(\frac{1}{VF_s\left(\frac{m^3}{kg}\right)} + \frac{1}{PEF_w\left(\frac{m^3}{kg}\right)}\right)}$$

Carcinogenic

Ingestion

$$SL_{rec\text{-}soil\text{-}ca\text{-}ing}\,(mg/kg) = \frac{TR \times AT_{rec}\left(\frac{365\ days}{year} \times LT\,(70\ years)\right)}{CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1} \times RBA \times IFS_{rec\text{-}adj}\left(\frac{mg}{kg}\right) \times \left(\frac{10^{-6}kg}{mg}\right)}$$

where:

$$IFS_{rec\text{-}adj}\left(\frac{mg}{kg}\right) = \left(\frac{ED_{rec\text{-}c}\,(6\ years) \times EF_{rec\text{-}c}\left(\frac{days}{year}\right) \times IRS_{rec\text{-}c}\left(\frac{200\ mg}{day}\right)}{BW_{rec\text{-}c}\,(15\ kg)} + \frac{ED_{rec\text{-}a}\,(20\ years) \times EF_{rec\text{-}a}\left(\frac{days}{year}\right) \times IRS_{rec\text{-}a}\left(\frac{100\ mg}{day}\right)}{BW_{rec\text{-}a}\,(80\ kg)}\right)$$

Dermal

$$SL_{rec\text{-}soil\text{-}ca\text{-}der}\,(mg/kg) = \frac{TR \times AT_{rec}\left(\frac{365\ days}{year} \times LT\,(70\ years)\right)}{\left(\frac{CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1}}{GIABS}\right) \times DFS_{rec\text{-}adj}\left(\frac{mg}{Kg}\right) \times ABS_d \times \left(\frac{10^{-6}kg}{mg}\right)}$$

where:

$$DFS_{rec\text{-}adj}\left(\frac{mg}{kg}\right) = \left(\frac{ED_{rec\text{-}c}\,(6\ years) \times EF_{rec\text{-}c}\left(\frac{days}{year}\right) \times SA_{rec\text{-}c}\left(\frac{2373\ cm^2}{day}\right) \times AF_{rec\text{-}c}\left(\frac{0.2mg}{cm^2}\right)}{BW_{rec\text{-}c}\,(15\ kg)} + \frac{ED_{rec\text{-}a}\,(20\ years) \times EF_{rec\text{-}a}\left(\frac{days}{year}\right) \times SA_{rec\text{-}a}\left(\frac{6032\ cm^2}{day}\right) \times AF_{rec\text{-}a}\left(\frac{0.07\ mg}{cm^2}\right)}{BW_{rec\text{-}a}\,(80\ kg)}\right)$$

Inhalation

$$SL_{rec\text{-}soil\text{-}ca\text{-}inh}\,(mg/kg) = \frac{TR \times AT_{rec}\left(\frac{365\ days}{year} \times LT\,(70\ years)\right)}{IUR\left(\mu g/m^3\right)^{-1} \times \left(\frac{1000\ \mu g}{mg}\right) \times EF_{rec}\left(\frac{days}{year}\right) \times \left(\frac{1}{VF_s\left(\frac{m^3}{kg}\right)} + \frac{1}{PEF_w\left(\frac{m^3}{kg}\right)}\right) \times ED_{rec}\,(26\ years) \times ET_{rec}\left(\frac{hours}{day}\right) \times \left(\frac{1\ day}{24\ hours}\right)}$$

Mutagenic

Ingestion

$$SL_{rec\text{-}soil\text{-}mu\text{-}ing}\left(mg/kg\right) = \frac{TR \times AT_{rec}\left(\frac{365\ days}{year} \times LT\left(70\ years\right)\right)}{CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1} \times RBA \times IFSM_{rec\text{-}adj}\left(\frac{mg}{kg}\right) \times \left(\frac{10^{-6} kg}{mg}\right)}$$

where:

$$IFSM_{rec\text{-}adj}\left(\frac{mg}{kg}\right) = \left(\begin{array}{l} \frac{ED_{0\text{-}2}\left(2\ years\right) \times EF_{0\text{-}2}\left(\frac{days}{year}\right) \times IRS_{0\text{-}2}\left(\frac{200\ mg}{day}\right) \times 10}{BW_{0\text{-}2}\left(15\ kg\right)} + \\ \frac{ED_{2\text{-}6}\left(4\ years\right) \times EF_{2\text{-}6}\left(\frac{days}{year}\right) \times IRS_{2\text{-}6}\left(\frac{200\ mg}{day}\right) \times 3}{BW_{2\text{-}6}\left(15\ kg\right)} + \\ \frac{ED_{6\text{-}16}\left(10\ years\right) \times EF_{6\text{-}16}\left(\frac{days}{year}\right) \times IRS_{6\text{-}16}\left(\frac{100\ mg}{day}\right) \times 3}{BW_{6\text{-}16}\left(80\ kg\right)} + \\ \frac{ED_{16\text{-}26}\left(10\ years\right) \times EF_{16\text{-}26}\left(\frac{days}{year}\right) \times IRS_{16\text{-}26}\left(\frac{100\ mg}{day}\right) \times 1}{BW_{16\text{-}26}\left(80\ kg\right)} \end{array}\right)$$

Dermal

$$SL_{rec\text{-}soil\text{-}mu\text{-}der}\left(mg/kg\right) = \frac{TR \times AT_{rec}\left(\frac{365\ days}{year} \times LT\left(70\ years\right)\right)}{\left(\frac{CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1}}{GIABS}\right) \times DFSM_{rec\text{-}adj}\left(\frac{mg}{kg}\right) \times ABS_d \times \left(\frac{10^{-6} kg}{mg}\right)}$$

where:

$$DFSM_{rec\text{-}adj}\left(\frac{mg}{kg}\right) = \left(\begin{array}{l} \frac{ED_{0\text{-}2}\left(2\ years\right) \times EF_{0\text{-}2}\left(\frac{days}{year}\right) \times AF_{0\text{-}2}\left(\frac{0.2\ mg}{cm^2}\right) \times SA_{0\text{-}2}\left(\frac{2373\ cm^2}{day}\right) \times 10}{BW_{0\text{-}2}\left(15\ kg\right)} + \\ \frac{ED_{2\text{-}6}\left(4\ years\right) \times EF_{2\text{-}6}\left(\frac{days}{year}\right) \times AF_{2\text{-}6}\left(\frac{0.2\ mg}{cm^2}\right) \times SA_{2\text{-}6}\left(\frac{2373\ cm^2}{day}\right) \times 3}{BW_{2\text{-}6}\left(15\ kg\right)} + \\ \frac{ED_{6\text{-}16}\left(10\ years\right) \times EF_{6\text{-}16}\left(\frac{days}{year}\right) \times AF_{6\text{-}16}\left(\frac{0.07\ mg}{cm^2}\right) \times SA_{6\text{-}16}\left(\frac{6032\ cm^2}{day}\right) \times 3}{BW_{6\text{-}16}\left(80\ kg\right)} + \\ \frac{ED_{16\text{-}26}\left(10\ years\right) \times EF_{16\text{-}26}\left(\frac{days}{year}\right) \times AF_{16\text{-}26}\left(\frac{0.07\ mg}{cm^2}\right) \times SA_{16\text{-}26}\left(\frac{6032\ cm^2}{day}\right) \times 1}{BW_{16\text{-}26}\left(80\ kg\right)} \end{array}\right)$$

Inhalation

$$SL_{rec\text{-}soil\text{-}mu\text{-}inh}(mg/kg) = \frac{TR \times AT_{rec}\left(\frac{365\ days}{year} \times LT\ (70\ years)\right)}{IUR\left(\mu g/m^3\right)^{-1} \times \left(\frac{1}{VF_s\left(\frac{m^3}{kg}\right)} + \frac{1}{PEF_w\left(\frac{m^3}{kg}\right)}\right) \times \left(\frac{1000\ \mu g}{mg}\right) \times \left(\begin{array}{l}\left(ED_{0\text{-}2}\ (2\ years) \times EF_{0\text{-}2}\left(\frac{days}{year}\right) \times ET_{0\text{-}2}\left(\frac{hours}{day}\right) \times \left(\frac{1\ day}{24\ hours}\right) \times 10\right) + \\ \left(ED_{2\text{-}6}\ (4\ years) \times EF_{2\text{-}6}\left(\frac{days}{year}\right) \times ET_{2\text{-}6}\left(\frac{hours}{day}\right) \times \left(\frac{1\ day}{24\ hours}\right) \times 3\right) + \\ \left(ED_{6\text{-}16}\ (10\ years) \times EF_{6\text{-}16}\left(\frac{days}{year}\right) \times ET_{6\text{-}16}\left(\frac{hours}{day}\right) \times \left(\frac{1\ day}{24\ hours}\right) \times 3\right) + \\ \left(ED_{16\text{-}26}\ (10\ years) \times EF_{16\text{-}26}\left(\frac{days}{year}\right) \times ET_{16\text{-}26}\left(\frac{hours}{day}\right) \times \left(\frac{1\ day}{24\ hours}\right) \times 1\right)\end{array}\right)}$$

Vinyl Chloride

Ingestion

$$SL_{rec\text{-}soil\text{-}ca\text{-}vc\text{-}ing}(mg/kg) = \frac{TR}{\left(\frac{CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1} \times RBA \times IFS_{rec\text{-}adj}\left(\frac{mg}{kg}\right) \times \frac{10^{-6} kg}{1\ mg}}{AT_{rec}\left(\frac{365\ days}{year} \times LT\ (70\ years)\right)}\right) + \left(\frac{CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1} \times RBA \times IRS_{rec\text{-}c}\left(\frac{200\ mg}{day}\right) \times \frac{10^{-6} kg}{1\ mg}}{BW_{rec\text{-}c}\ (15\ kg)}\right)}$$

Dermal

$$SL_{rec\text{-}soil\text{-}ca\text{-}vc\text{-}der}\,(mg/kg) = \frac{TR}{\left(\dfrac{\dfrac{CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1}}{GIABS} \times DFS_{rec\text{-}adj}\left(\frac{mg}{kg}\right) \times ABS_d \times \frac{10^{-6}kg}{1\ mg}}{AT_{rec}\left(\frac{365\ days}{year} \times LT\,(70\ years)\right)}\right) + \left(\dfrac{\dfrac{CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1}}{GIABS} \times SA_{rec\text{-}c}\left(\frac{2373\ cm^2}{day}\right) \times AF_{rec\text{-}c}\left(\frac{0.2\ mg}{cm^2}\right) \times ABS \times \frac{10^{-6}kg}{1\ mg}}{BW_{rec\text{-}c}\,(15\ kg)}\right)}$$

Inhalation

$$SL_{rec\text{-}soil\text{-}ca\text{-}vc\text{-}inh}\,(mg/kg) = \frac{TR}{\left(\dfrac{IUR\left(\frac{\mu g}{m^3}\right)^{-1} \times EF_{rec}\left(\frac{days}{year}\right) \times ED_{rec}\,(26\ years) \times ET_{rec}\left(\frac{hours}{day}\right) \times \left(\frac{1\ day}{24\ hours}\right) \times \left(\frac{1000\ \mu g}{mg}\right)}{AT_{rec}\left(\frac{365\ days}{year} \times LT\,(70\ years)\right) \times VF_s\left(\frac{m^3}{kg}\right)}\right) + \left(\dfrac{IUR\left(\frac{\mu g}{m^3}\right)^{-1}}{VF_s\left(\frac{m^3}{kg}\right)} \times \left(\frac{1000\ \mu g}{mg}\right)\right)}$$

Trichloroethylene

Ingestion

$$SL_{rec\text{-}soil\text{-}tce\text{-}ing}(mg/kg) = \frac{TR \times AT_{rec}\left(\frac{365\ days}{year} \times LT\,(70\ years)\right)}{CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1} \times RBA \times \left(\frac{10^{-6}\ kg}{mg}\right) \times \left(\left(CAF_o\,(0.804) \times IFS_{rec\text{-}adj}\left(\frac{mg}{kg}\right)\right) + \left(MAF_o\,(0.202) \times IFSM_{rec\text{-}adj}\left(\frac{mg}{kg}\right)\right)\right)}$$

where:

$$IFS_{rec\text{-}adj}\left(\frac{mg}{kg}\right) = \left(\frac{ED_{rec\text{-}c}\,(6\ years) \times EF_{rec\text{-}c}\left(\frac{days}{year}\right) \times IRS_{rec\text{-}c}\left(\frac{200\ mg}{day}\right)}{BW_{rec\text{-}c}\,(15\ kg)} + \frac{\left(ED_{rec}\,(26\ years) - ED_{rec\text{-}c}\,(6\ years)\right) \times EF_{rec\text{-}a}\left(\frac{days}{year}\right) \times IRS_{rec\text{-}a}\left(\frac{100\ mg}{day}\right)}{BW_{rec\text{-}a}\,(80\ kg)}\right)$$

where:

$$IFSM_{rec\text{-}adj\text{-}}\left(\frac{mg}{kg}\right) = \left(\frac{ED_{0\text{-}2}\,(2\ years) \times EF_{0\text{-}2}\left(\frac{days}{year}\right) \times IRS_{0\text{-}2}\left(\frac{200\ mg}{day}\right) \times 10}{BW_{0\text{-}2}\,(15\ kg)} + \frac{ED_{2\text{-}6}\,(4\ years) \times EF_{2\text{-}6}\left(\frac{days}{year}\right) \times IRS_{2\text{-}6}\left(\frac{200\ mg}{day}\right) \times 3}{BW_{2\text{-}6}\,(15\ kg)} + \frac{ED_{6\text{-}16}\,(10\ years) \times EF_{6\text{-}16}\left(\frac{days}{year}\right) \times IRS_{6\text{-}16}\left(\frac{100\ mg}{day}\right) \times 3}{BW_{6\text{-}16}\,(80\ kg)} + \frac{ED_{16\text{-}26}\,(10\ years) \times EF_{16\text{-}26}\left(\frac{days}{year}\right) \times IRS_{16\text{-}26}\left(\frac{100\ mg}{day}\right) \times 1}{BW_{16\text{-}26}\,(80\ kg)}\right)$$

Dermal

$$SL_{rec\text{-}soil\text{-}tce\text{-}der}(mg/kg) = \frac{TR \times AT_{rec}\left(\frac{365\ days}{year} \times LT\,(70\ years)\right)}{\left(\frac{CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1}}{GIABS}\right) \times \left(\frac{10^{-6}kg}{mg}\right) \times \left(\left(CAF_o\,(0.804) \times DFS_{rec\text{-}adj}\left(\frac{mg}{kg}\right) \times ABS_d\right) + \left(MAF_o\,(0.202) \times DFSM_{rec\text{-}adj}\left(\frac{mg}{kg}\right) \times ABS_d\right)\right)}$$

where:

$$DFS_{rec\text{-}adj}\left(\frac{mg}{kg}\right) = \left(\frac{ED_{rec\text{-}c}\,(6\ years) \times EF_{rec\text{-}c}\left(\frac{days}{year}\right) \times SA_{rec\text{-}c}\left(\frac{2373\ cm^2}{day}\right) \times AF_{rec\text{-}c}\left(\frac{0.2\ mg}{cm^2}\right)}{BW_{rec\text{-}c}\,(15\ kg)} + \frac{\left(ED_{rec}\,(26\ years) - ED_{rec\text{-}c}\,(6\ years)\right) \times EF_{rec\text{-}a}\left(\frac{days}{year}\right) \times SA_{rec\text{-}a}\left(\frac{6032\ cm^2}{day}\right) \times AF_{rec\text{-}a}\left(\frac{0.07\ mg}{cm^2}\right)}{BW_{rec\text{-}a}\,(80\ kg)}\right)$$

where:

$$DFSM_{rec\text{-}adj}\left(\frac{mg}{kg}\right) = \left(\begin{array}{l}\frac{ED_{0\text{-}2}\,(2\ years) \times EF_{0\text{-}2}\left(\frac{days}{year}\right) \times AF_{0\text{-}2}\left(\frac{0.2\ mg}{cm^2}\right) \times SA_{0\text{-}2}\left(\frac{2373\ cm^2}{day}\right) \times 10}{BW_{0\text{-}2}\,(15\ kg)} + \\ \frac{ED_{2\text{-}6}\,(4\ years) \times EF_{2\text{-}6}\left(\frac{days}{year}\right) \times AF_{2\text{-}6}\left(\frac{0.2\ mg}{cm^2}\right) \times SA_{2\text{-}6}\left(\frac{2373\ cm^2}{day}\right) \times 3}{BW_{2\text{-}6}\,(15\ kg)} + \\ \frac{ED_{6\text{-}16}\,(10\ years) \times EF_{6\text{-}16}\left(\frac{days}{year}\right) \times AF_{6\text{-}16}\left(\frac{0.07\ mg}{cm^2}\right) \times SA_{6\text{-}16}\left(\frac{6032\ cm^2}{day}\right) \times 3}{BW_{6\text{-}16}\,(80\ kg)} + \\ \frac{ED_{16\text{-}26}\,(10\ years) \times EF_{16\text{-}26}\left(\frac{days}{year}\right) \times AF_{16\text{-}26}\left(\frac{0.07\ mg}{cm^2}\right) \times SA_{16\text{-}26}\left(\frac{6032\ cm^2}{day}\right) \times 1}{BW_{16\text{-}26}\,(80\ kg)}\end{array}\right)$$

Inhalation

$$SL_{rec\text{-}soil\text{-}tce\text{-}inh}(mg/kg) = \frac{TR \times AT_{rec}\left(\frac{365\ days}{year} \times LT\,(70\ years)\right)}{\begin{array}{c}IUR\left(\mu g/m^3\right)^{-1} \times \left(\frac{1}{VF_s\left(\frac{m^3}{kg}\right)} + \frac{1}{PEF_w\left(\frac{m^3}{kg}\right)}\right) \times \left(\frac{1000\ \mu g}{mg}\right) \times \left(\frac{1\ day}{24\ hours}\right) \times \\ \left(\left(\begin{array}{l}CAF_i\,(0.756) \times EF_{rec}\left(\frac{days}{year}\right) \times \\ ED_{rec}\,(26\ years) \times ET_{rec}\left(\frac{hours}{day}\right)\end{array}\right) + \left(\begin{array}{l}\left(ED_{0\text{-}2}\,(2\ years) \times EF_{0\text{-}2}\left(\frac{days}{year}\right) \times ET_{0\text{-}2}\left(\frac{hours}{day}\right) \times MAF_i\,(0.244) \times 10\right) + \\ \left(ED_{2\text{-}6}\,(4\ years) \times EF_{2\text{-}6}\left(\frac{days}{year}\right) \times ET_{2\text{-}6}\left(\frac{hours}{day}\right) \times MAF_i\,(0.244) \times 3\right) + \\ \left(ED_{6\text{-}16}\,(10\ years) \times EF_{6\text{-}16}\left(\frac{days}{year}\right) \times ET_{6\text{-}16}\left(\frac{hours}{day}\right) \times MAF_i\,(0.244) \times 3\right) + \\ \left(ED_{16\text{-}26}\,(10\ years) \times EF_{16\text{-}26}\left(\frac{days}{year}\right) \times ET_{16\text{-}26}\left(\frac{hours}{day}\right) \times MAF_i\,(0.244) \times 1\right)\end{array}\right)\right)\end{array}}$$

Supporting Equations

Child

$$ED_{rec\text{-}c}\,(6\text{ years}) = ED_{0\text{-}2}\,(2\text{ years}) + ED_{2\text{-}6}\,(4\text{ years})$$

$$BW_{rec\text{-}c}\,(15\text{ kg}) = \frac{BW_{0\text{-}2}\,(15\text{ kg}) \times ED_{0\text{-}2}\,(2\text{ years}) + BW_{2\text{-}6}\,(15\text{ kg}) \times ED_{2\text{-}6}\,(4\text{ years})}{ED_{0\text{-}2}\,(2\text{ years}) + ED_{2\text{-}6}\,(4\text{ years})}$$

$$AF_{rec\text{-}c}\left(\frac{0.2\text{ events}}{\text{day}}\right) = \frac{AF_{0\text{-}2}\left(\frac{0.2\text{ events}}{\text{day}}\right) \times ED_{0\text{-}2}\,(2\text{ years}) + AF_{2\text{-}6}\left(\frac{0.2\text{ events}}{\text{day}}\right) \times ED_{2\text{-}6}\,(4\text{ years})}{ED_{0\text{-}2}\,(2\text{ years}) + ED_{2\text{-}6}\,(4\text{ years})}$$

$$EF_{rec\text{-}c}\left(\frac{\text{days}}{\text{year}}\right) = \frac{EF_{0\text{-}2}\left(\frac{\text{days}}{\text{year}}\right) \times ED_{0\text{-}2}\,(2\text{ years}) + EF_{2\text{-}6}\left(\frac{\text{days}}{\text{year}}\right) \times ED_{2\text{-}6}\,(4\text{ years})}{ED_{0\text{-}2}\,(2\text{ years}) + ED_{2\text{-}6}\,(4\text{ years})}$$

$$ET_{rec\text{-}c}\left(\frac{\text{hours}}{\text{day}}\right) = \frac{ET_{0\text{-}2}\left(\frac{\text{hours}}{\text{day}}\right) \times ED_{0\text{-}2}\,(2\text{ years}) + ET_{2\text{-}6}\left(\frac{\text{hours}}{\text{day}}\right) \times ED_{2\text{-}6}\,(4\text{ years})}{ED_{0\text{-}2}\,(2\text{ years}) + ED_{2\text{-}6}\,(4\text{ years})}$$

$$SA_{rec\text{-}c}\left(\frac{2373\text{ cm}^2}{\text{day}}\right) = \frac{SA_{0\text{-}2}\left(\frac{2373\text{ cm}^2}{\text{day}}\right) \times ED_{0\text{-}2}\,(2\text{ years}) + SA_{2\text{-}6}\left(\frac{2373\text{ cm}^2}{\text{day}}\right) \times ED_{2\text{-}6}\,(4\text{ years})}{ED_{0\text{-}2}\,(2\text{ years}) + ED_{2\text{-}6}\,(4\text{ years})}$$

$$IRS_{rec\text{-}c}\left(\frac{200\text{ mg}}{\text{day}}\right) = \frac{IRS_{0\text{-}2}\left(\frac{200\text{ mg}}{\text{day}}\right) \times ED_{0\text{-}2}\,(2\text{ years}) + IRS_{2\text{-}6}\left(\frac{200\text{ mg}}{\text{day}}\right) \times ED_{2\text{-}6}\,(4\text{ years})}{ED_{0\text{-}2}\,(2\text{ years}) + ED_{2\text{-}6}\,(4\text{ years})}$$

Adult

$$ED_{rec\text{-}a}\,(20\ years) = ED_{6\text{-}16}\,(10\ years) + ED_{16\text{-}26}\,(10\ years)$$

$$BW_{rec\text{-}a}\,(80\ kg) = \frac{BW_{6\text{-}16}\,(80\ kg) \times ED_{6\text{-}16}\,(10\ years) + BW_{16\text{-}26}\,(80\ kg) \times ED_{16\text{-}26}\,(10\ years)}{ED_{6\text{-}16}\,(10\ years) + ED_{16\text{-}26}\,(10\ years)}$$

$$AF_{rec\text{-}a}\left(\frac{0.07\ events}{day}\right) = \frac{AF_{6\text{-}16}\left(\frac{0.07\ events}{day}\right) \times ED_{6\text{-}16}\,(10\ years) + AF_{16\text{-}26}\left(\frac{0.07\ events}{day}\right) \times ED_{16\text{-}26}\,(10\ years)}{ED_{6\text{-}16}\,(10\ years) + ED_{16\text{-}26}\,(10\ years)}$$

$$EF_{rec\text{-}a}\left(\frac{days}{year}\right) = \frac{EF_{6\text{-}16}\left(\frac{days}{year}\right) \times ED_{6\text{-}16}\,(10\ years) + EF_{16\text{-}26}\left(\frac{days}{year}\right) \times ED_{16\text{-}26}\,(10\ years)}{ED_{6\text{-}16}\,(10\ years) + ED_{16\text{-}26}\,(10\ years)}$$

$$ET_{rec\text{-}a}\left(\frac{hours}{day}\right) = \frac{ET_{6\text{-}16}\left(\frac{hours}{day}\right) \times ED_{6\text{-}16}\,(10\ years) + ET_{16\text{-}26}\left(\frac{hours}{day}\right) \times ED_{16\text{-}26}\,(10\ years)}{ED_{6\text{-}16}\,(10\ years) + ED_{16\text{-}26}\,(10\ years)}$$

$$SA_{rec\text{-}a}\left(\frac{6032\ cm^2}{day}\right) = \frac{SA_{6\text{-}16}\left(\frac{6032\ cm^2}{day}\right) \times ED_{6\text{-}16}\,(10\ years) + SA_{16\text{-}26}\left(\frac{6032\ cm^2}{day}\right) \times ED_{16\text{-}26}\,(10\ years)}{ED_{6\text{-}16}\,(10\ years) + ED_{16\text{-}26}\,(10\ years)}$$

$$IRS_{rec\text{-}a}\left(\frac{100\ mg}{day}\right) = \frac{IRS_{6\text{-}16}\left(\frac{100\ mg}{day}\right) \times ED_{6\text{-}16}\,(10\ years) + IRS_{16\text{-}26}\left(\frac{100\ mg}{day}\right) \times ED_{16\text{-}26}\,(10\ years)}{ED_{6\text{-}16}\,(10\ years) + ED_{16\text{-}26}\,(10\ years)}$$

Age-Adjusted

$$ED_{rec}\,(26\ years) = ED_{0\text{-}2}\,(2\ years) + ED_{2\text{-}6}\,(4\ years) + ED_{6\text{-}16}\,(10\ years) + ED_{16\text{-}26}\,(10\ years)$$

$$EF_{rec}\left(\frac{days}{year}\right) = \frac{EF_{0\text{-}2}\left(\frac{days}{year}\right) \times ED_{0\text{-}2}\,(2\ years) + EF_{2\text{-}6}\left(\frac{days}{year}\right) \times ED_{2\text{-}6}\,(4\ years) + EF_{6\text{-}16}\left(\frac{days}{year}\right) \times ED_{6\text{-}16}\,(10\ years) + EF_{16\text{-}26}\left(\frac{days}{year}\right) \times ED_{16\text{-}26}\,(10\ years)}{ED_{0\text{-}2}\,(2\ years) + ED_{2\text{-}6}\,(4\ years) + ED_{6\text{-}16}\,(10\ years) + ED_{16\text{-}26}\,(10\ years)}$$

$$ET_{rec}\left(\frac{hours}{day}\right) = \frac{ET_{0\text{-}2}\left(\frac{hours}{day}\right) \times ED_{0\text{-}2}\,(2\ years) + ET_{2\text{-}6}\left(\frac{hours}{day}\right) \times ED_{2\text{-}6}\,(4\ years) + ET_{6\text{-}16}\left(\frac{hours}{day}\right) \times ED_{6\text{-}16}\,(10\ years) + ET_{16\text{-}26}\left(\frac{hours}{day}\right) \times ED_{16\text{-}26}\,(10\ years)}{ED_{0\text{-}2}\,(2\ years) + ED_{2\text{-}6}\,(4\ years) + ED_{6\text{-}16}\,(10\ years) + ED_{16\text{-}26}\,(10\ years)}$$

A1.4.2 Surface Water

<u>Noncarcinogenic Child</u>

Ingestion

$$SL_{rec\text{-}water\text{-}nc\text{-}ing\text{-}c}\,(\mu g/L) = \frac{THQ \times AT_{rec\text{-}c}\left(\frac{365\ days}{year} \times ED_{rec\text{-}c}\,(6\ years)\right) \times BW_{rec\text{-}c}\,(15\ kg) \times \left(\frac{1000\ \mu g}{mg}\right)}{EF_{rec\text{-}c}\left(\frac{days}{year}\right) \times ED_{rec\text{-}c}\,(6\ years) \times \frac{1}{RfD_o\left(\frac{mg}{kg\text{-}d}\right)} \times IRW_{rec\text{-}c}\left(\frac{0.12\ L}{hour}\right) \times EV_{rec\text{-}c}\left(\frac{events}{day}\right) \times ET_{rec\text{-}c}\left(\frac{hours}{event}\right)}$$

Dermal

FOR INORGANICS:

$$SL_{rec\text{-}water\text{-}nc\text{-}der\text{-}c}\,(\mu g/L) = \frac{DA_{event}\left(\frac{ug}{cm^2\text{-}\ event}\right) \times \left(\frac{1000\ cm^3}{L}\right)}{K_p\left(\frac{cm}{hour}\right) \times ET_{event\text{-}rec\text{-}c}\left(\frac{hours}{event}\right)}$$

FOR ORGANICS:

$$\text{IF } ET_{event\text{-}rec\text{-}c}\left(\frac{hours}{event}\right) \leq t^*\,(hour)\text{, then } SL_{rec\text{-}water\text{-}nc\text{-}der}\,(\mu g/L) = \frac{DA_{event}\left(\frac{ug}{cm^2\text{-}\ event}\right) \times \left(\frac{1000\ cm^3}{L}\right)}{2 \times FA \times K_p\left(\frac{cm}{hour}\right)\sqrt{\frac{6 \times \tau_{event}\left(\frac{hours}{event}\right) \times ET_{event\text{-}rec\text{-}c}\left(\frac{hours}{event}\right)}{\pi}}}$$

or,

$$\text{IF } ET_{event\text{-}rec\text{-}c}\left(\frac{hours}{event}\right) > t^*\,(hour)\text{, then } SL_{rec\text{-}water\text{-}nc\text{-}der}\,(\mu g/L) = \frac{DA_{event}\left(\frac{ug}{cm^2\text{-}\ event}\right) \times \left(\frac{1000\ cm^3}{L}\right)}{FA \times K_p\left(\frac{cm}{hour}\right) \times \left[\frac{ET_{event\text{-}rec\text{-}c}\left(\frac{hours}{event}\right)}{1+B} + 2 \times \tau_{event}\left(\frac{hours}{event}\right) \times \left(\frac{1+3B+3B^2}{(1+B)^2}\right)\right]}$$

where:

$$DA_{event}\left(\frac{ug}{cm^2\text{-}\ event}\right) = \frac{THQ \times AT_{rec\text{-}c}\left(\frac{365\ days}{year} \times ED_{rec\text{-}c}\,(6\ years)\right) \times \left(\frac{1000\ \mu g}{mg}\right) \times BW_{rec\text{-}c}\,(15\ kg)}{\left(\frac{1}{RfD_o\left(\frac{mg}{kg\text{-}day}\right) \times GIABS}\right) \times EV_{rec\text{-}c}\left(\frac{events}{day}\right) \times ED_{rec\text{-}c}\,(6\ years) \times EF_{rec\text{-}c}\left(\frac{days}{year}\right) \times SA_{rec\text{-}c}\left(6365\ cm^2\right)}$$

Noncarcinogenic Adult

Ingestion

$$SL_{rec\text{-}wat\text{-}nc\text{-}ing\text{-}a}\,(\mu g/L) = \frac{THQ \times AT_{rec\text{-}a}\left(\frac{365\ days}{year} \times ED_{rec\text{-}a}\,(20\ years)\right) \times BW_{rec\text{-}a}\,(80\ kg) \times \left(\frac{1000\ \mu g}{mg}\right)}{EF_{rec\text{-}a}\left(\frac{days}{year}\right) \times ED_{rec\text{-}a}\,(20\ years) \times \frac{1}{RfD_o\left(\frac{mg}{kg\text{-}d}\right)} \times IRW_{rec\text{-}a}\left(\frac{0.11\ L}{hour}\right) \times EV_{rec\text{-}a}\left(\frac{events}{day}\right) \times ET_{event\text{-}rec\text{-}a}\left(\frac{hours}{event}\right)}$$

Dermal

FOR INORGANICS:

$$SL_{rec\text{-}water\text{-}nc\text{-}der\text{-}a}\,(\mu g/L) = \frac{DA_{event}\left(\frac{ug}{cm^2\text{-}\ event}\right)\times\left(\frac{1000\ cm^3}{L}\right)}{K_p\left(\frac{cm}{hour}\right)\times ET_{event\text{-}rec\text{-}c}\left(\frac{hours}{event}\right)}$$

FOR ORGANICS:

$$\text{IF } ET_{event\text{-}rec\text{-}a}\left(\frac{hours}{event}\right) \le t^{*}\,(hour)\text{, then } SL_{rec\text{-}water\text{-}nc\text{-}der}\,(\mu g/L) = \frac{DA_{event}\left(\frac{ug}{cm^2\text{-}\ event}\right)\times\left(\frac{1000\ cm^3}{L}\right)}{2\times FA\times K_p\left(\frac{cm}{hour}\right)\sqrt{\frac{6\times\tau_{event}\left(\frac{hours}{event}\right)\times ET_{event\text{-}rec\text{-}a}\left(\frac{hours}{event}\right)}{\pi}}}$$

or,

$$\text{IF } ET_{event\text{-}rec\text{-}a}\left(\frac{hours}{event}\right) > t^{*}\,(hour)\text{, then } SL_{rec\text{-}water\text{-}nc\text{-}der}\,(\mu g/L) = \frac{DA_{event}\left(\frac{ug}{cm^2\text{-}\ event}\right)\times\left(\frac{1000\ cm^3}{L}\right)}{FA\times K_p\left(\frac{cm}{hour}\right)\times\left[\frac{ET_{event\text{-}rec\text{-}a}\left(\frac{hours}{event}\right)}{1+B}+2\times\tau_{event}\left(\frac{hours}{event}\right)\times\left(\frac{1+3B+3B^2}{(1+B)^2}\right)\right]}$$

where:

$$DA_{event}\left(\frac{ug}{cm^2\text{-}\ event}\right) = \frac{THQ\times AT_{rec\text{-}a}\left(\frac{365\ days}{year}\times ED_{rec\text{-}a}\,(20\ years)\right)\times\left(\frac{1000\ \mu g}{mg}\right)\times BW_{rec\text{-}a}\,(80\ kg)}{\left(\frac{1}{RfD_o\left(\frac{mg}{kg\text{-}day}\right)\times GIABS}\right)\times EV_{rec\text{-}a}\left(\frac{events}{day}\right)\times ED_{rec\text{-}a}\,(20\ years)\times EF_{rec\text{-}a}\left(\frac{days}{year}\right)\times SA_{rec\text{-}a}\left(19652\ cm^2\right)}$$

<u>Carcinogenic</u>

Ingestion

$$SL_{rec\text{-}water\text{-}ca\text{-}ing}\,(\mu g/L) = \frac{TR\times AT_{rec}\left(\frac{365\ days}{year}\times LT\,(70\ years)\right)\times\left(\frac{1000\ \mu g}{mg}\right)}{CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1}\times IFW_{rec\text{-}adj}\left(\frac{L}{kg}\right)}$$

where:

$$IFW_{rec\text{-}adj}\left(\frac{L}{kg}\right) = \left(\begin{array}{c}\frac{EV_{rec\text{-}c}\left(\frac{events}{day}\right)\times ED_{rec\text{-}c}\,(6\ years)\times EF_{rec\text{-}c}\left(\frac{days}{year}\right)\times ET_{rec\text{-}c}\left(\frac{hours}{event}\right)\times IRW_{rec\text{-}c}\left(\frac{0.12\ L}{hour}\right)}{BW_{rec\text{-}c}\,(15\ kg)}+\\ \frac{EV_{rec\text{-}a}\left(\frac{events}{day}\right)\times ED_{rec\text{-}a}\,(20\ years)\times EF_{rec\text{-}a}\left(\frac{days}{year}\right)\times ET_{rec\text{-}a}\left(\frac{hours}{event}\right)\times IRW_{rec\text{-}a}\left(\frac{0.071\ L}{hour}\right)}{BW_{rec\text{-}a}\,(80\ kg)}\end{array}\right)$$

Dermal

FOR INORGANICS:

$$SL_{rec\text{-}water\text{-}ca\text{-}der}\,(\mu g/L) = \frac{DA_{event}\left(\frac{ug}{cm^2\text{- event}}\right)\times\left(\frac{1000\ cm^3}{L}\right)}{K_p\left(\frac{cm}{hour}\right)\times ET_{event\text{-}rec\text{-}adj}\left(\frac{hours}{event}\right)}$$

FOR ORGANICS:

$$\text{IF } ET_{event\text{-}rec\text{-}adj}\left(\frac{hours}{event}\right) \le t^*\,(hour)\text{, then } SL_{rec\text{-}water\text{-}ca\text{-}der}\,(\mu g/L) = \frac{DA_{event}\left(\frac{ug}{cm^2\text{- event}}\right)\times\left(\frac{1000\ cm^3}{L}\right)}{2\times FA\times K_p\left(\frac{cm}{hour}\right)\sqrt{\frac{6\times\tau_{event}\left(\frac{hours}{event}\right)\times ET_{event\text{-}rec\text{-}adj}\left(\frac{hours}{event}\right)}{\pi}}}$$

or,

$$\text{IF } ET_{event\text{-}rec\text{-}adj}\left(\frac{hours}{event}\right) > t^*\,(hour)\text{, then } SL_{rec\text{-}water\text{-}ca\text{-}der}\,(\mu g/L) = \frac{DA_{event}\left(\frac{ug}{cm^2\text{- event}}\right)\times\left(\frac{1000\ cm^3}{L}\right)}{FA\times K_p\left(\frac{cm}{hour}\right)\times\left[\frac{ET_{event\text{-}rec\text{-}adj}\left(\frac{hours}{event}\right)}{1+B}+2\times\tau_{event}\left(\frac{hours}{event}\right)\times\left(\frac{1+3B+3B^2}{(1+B)^2}\right)\right]}$$

where:

$$DA_{event}\left(\frac{ug}{cm^2\text{- event}}\right) = \frac{TR\times AT_{rec}\left(\frac{365\ days}{year}\times LT(70\ years)\right)\times\left(\frac{1000\ \mu g}{mg}\right)}{\left(\frac{CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1}}{GIABS}\right)\times DFW_{rec\text{-}adj}\left(\frac{events\text{-}cm^2}{kg}\right)}$$

where:

$$DFW_{rec\text{-}adj}\left(\frac{events\text{-}cm^2}{kg}\right) = \left(\frac{EV_{rec\text{-}c}\left(\frac{events}{day}\right)\times ED_{rec\text{-}c}(6\ years)\times EF_{rec\text{-}c}\left(\frac{days}{year}\right)\times SA_{rec\text{-}c}\left(6365\ cm^2\right)}{BW_{rec\text{-}c}(15\ kg)}+\frac{EV_{rec\text{-}a}\left(\frac{events}{day}\right)\times ED_{rec\text{-}a}(20\ years)\times EF_{rec\text{-}a}\left(\frac{days}{year}\right)\times SA_{rec\text{-}a}\left(19652\ cm^2\right)}{BW_{rec\text{-}a}(80\ kg)}\right)$$

and:

$$ET_{event\text{-}rec\text{-}adj}\left(\frac{hours}{event}\right) = \left(\frac{\left(ET_{event\text{-}rec\text{-}c}\left(\frac{hours}{event}\right)\times ED_{rec\text{-}c}(6\ years)+ET_{event\text{-}rec\text{-}a}\left(\frac{hours}{event}\right)\times ED_{rec\text{-}a}(20\ years)\right)}{ED_{rec\text{-}c}(6\ years)+ED_{rec\text{-}a}(20\ years)}\right)$$

Mutagenic

Ingestion

$$SL_{rec\text{-}water\text{-}mu\text{-}ing}\,(\mu g/L) = \frac{TR \times AT_{rec}\left(\frac{365\ days}{year} \times LT\ (70\ years)\right) \times \left(\frac{1000\ \mu g}{mg}\right)}{CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1} \times IFWM_{rec\text{-}adj}\left(\frac{L}{kg}\right)}$$

where:

$$IFWM_{rec\text{-}adj}\left(\frac{L}{kg}\right) = \left(\begin{array}{c} \frac{ED_{0\text{-}2}\,(2\ years) \times EF_{0\text{-}2}\left(\frac{days}{year}\right) \times IRW_{0\text{-}2}\left(\frac{0.12\ L}{hour}\right) \times EV_{0\text{-}2}\left(\frac{events}{day}\right) \times ET_{0\text{-}2}\left(\frac{hours}{event}\right) \times 10}{BW_{0\text{-}2}\,(15\ kg)} + \\ \frac{ED_{2\text{-}6}\,(4\ years) \times EF_{2\text{-}6}\left(\frac{days}{year}\right) \times IRW_{2\text{-}6}\left(\frac{0.12\ L}{hour}\right) \times EV_{2\text{-}6}\left(\frac{events}{day}\right) \times ET_{2\text{-}6}\left(\frac{hours}{event}\right) \times 3}{BW_{2\text{-}6}\,(15\ kg)} + \\ \frac{ED_{6\text{-}16}\,(10\ years) \times EF_{6\text{-}16}\left(\frac{days}{year}\right) \times IRW_{6\text{-}16}\left(\frac{0.071\ L}{hour}\right) \times EV_{6\text{-}16}\left(\frac{events}{day}\right) \times ET_{6\text{-}16}\left(\frac{hours}{event}\right) \times 3}{BW_{6\text{-}16}\,(80\ kg)} + \\ \frac{ED_{16\text{-}26}\,(10\ years) \times EF_{16\text{-}26}\left(\frac{days}{year}\right) \times IRW_{16\text{-}26}\left(\frac{0.071\ L}{hour}\right) \times EV_{16\text{-}26}\left(\frac{events}{day}\right) \times ET_{16\text{-}26}\left(\frac{hours}{event}\right) \times 1}{BW_{16\text{-}26}\,(80\ kg)} \end{array}\right)$$

Dermal

FOR INORGANICS:

$$SL_{rec\text{-}water\text{-}mu\text{-}der}\,(\mu g/L) = \frac{DA_{event}\left(\frac{ug}{cm^2\text{-}\,event}\right)\times\left(\frac{1000\ cm^3}{L}\right)}{K_p\left(\frac{cm}{hour}\right)\times ET_{event\text{-}rec\text{-}madj}\left(\frac{hours}{event}\right)}$$

FOR ORGANICS:

$$\text{IF } ET_{event\text{-}rec\text{-}madj}\left(\frac{hours}{event}\right) \le t^{*}\ (hours), \text{then } SL_{rec\text{-}water\text{-}mu\text{-}der}\,(\mu g/L) = \frac{DA_{event}\left(\frac{ug}{cm^2\text{-}\,event}\right)\times\left(\frac{1000\ cm^3}{L}\right)}{2\times FA\times K_p\left(\frac{cm}{hour}\right)\sqrt{\frac{6\times\tau_{event}\left(\frac{hours}{event}\right)\times ET_{event\text{-}rec\text{-}madj}\left(\frac{hours}{event}\right)}{\pi}}}$$

or,

$$\text{IF } ET_{event\text{-}rec\text{-}madj}\left(\frac{hours}{event}\right) > t^{*}\ (hours), \text{then } SL_{rec\text{-}water\text{-}mu\text{-}der}\,(\mu g/L) = \frac{DA_{event}\left(\frac{ug}{cm^2\text{-}\,event}\right)\times\left(\frac{1000\ cm^3}{L}\right)}{FA\times K_p\left(\frac{cm}{hour}\right)\times\left[\frac{ET_{event\text{-}rec\text{-}madj}\left(\frac{hours}{event}\right)}{1+B}+2\times\tau_{event}\left(\frac{hours}{event}\right)\times\left(\frac{1+3B+3B^2}{(1+B)^2}\right)\right]}$$

where:

$$DA_{event}\left(\frac{ug}{cm^2\text{-}\,event}\right) = \frac{TR\times AT_{rec}\left(\frac{365\ days}{year}\times LT\ (70\ years)\right)\times\left(\frac{1000\ \mu g}{mg}\right)}{\left(\frac{CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1}}{GIABS}\right)\times DFWM_{rec\text{-}adj}\left(\frac{events\text{-}\,cm^2}{kg}\right)}$$

where:

$$DFWM_{rec\text{-}adj}\left(\frac{events\text{-}\,cm^2}{kg}\right) = \left[\begin{array}{l}\left(\frac{EV_{0\text{-}2}\left(\frac{events}{day}\right)\times ED_{0\text{-}2}\ (2\ years)\times EF_{0\text{-}2}\left(\frac{days}{year}\right)\times SA_{0\text{-}2}\left(6365\ cm^2\right)\times 10}{BW_{0\text{-}2}\ (15\ kg)}\right)+\\ \left(\frac{EV_{2\text{-}6}\left(\frac{events}{day}\right)\times ED_{2\text{-}6}\ (4\ years)\times EF_{2\text{-}6}\left(\frac{days}{year}\right)\times SA_{2\text{-}6}\left(6365\ cm^2\right)\times 3}{BW_{2\text{-}6}\ (15\ kg)}\right)+\\ \left(\frac{EV_{6\text{-}16}\left(\frac{events}{day}\right)\times ED_{6\text{-}16}\ (10\ years)\times EF_{6\text{-}16}\left(\frac{days}{year}\right)\times SA_{6\text{-}16}\left(19652\ cm^2\right)\times 3}{BW_{6\text{-}16}\ (80\ kg)}\right)+\\ \left(\frac{EV_{16\text{-}26}\left(\frac{events}{day}\right)\times ED_{16\text{-}26}\ (10\ years)\times EF_{16\text{-}26}\left(\frac{days}{year}\right)\times SA_{16\text{-}26}\left(19652\ cm^2\right)\times 1}{BW_{16\text{-}26}\ (80\ kg)}\right)\end{array}\right]$$

and:

$$ET_{event\text{-}rec\text{-}madj}\left(\frac{hours}{event}\right) = \frac{\left(\begin{array}{l}ET_{event\text{-}rec(0\text{-}2)}\left(\frac{hours}{event}\right)\times ED_{0\text{-}2}\ (2\ years)+ET_{event\text{-}rec(2\text{-}6)}\left(\frac{hours}{event}\right)\times ED_{2\text{-}6}\ (4\ years)+\\ ET_{event\text{-}rec(6\text{-}16)}\left(\frac{hours}{event}\right)\times ED_{6\text{-}16}\ (10\ years)+ET_{event\text{-}rec(16\text{-}26)}\left(\frac{hours}{event}\right)\times ED_{16\text{-}26}\ (10\ years)\end{array}\right)}{ED_{0\text{-}2}\ (2\ years)+ED_{2\text{-}6}\ (4\ years)+ED_{6\text{-}16}\ (10\ years)+ED_{16\text{-}26}\ (10\ years)}$$

Vinyl Chloride

Ingestion

$$SL_{rec\text{-}water\text{-}ca\text{-}vc\text{-}ing}(\mu g/L) = \frac{TR}{\left(\frac{CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1} \times IFW_{rec\text{-}adj}\left(\frac{L}{kg}\right) \times \left(\frac{mg}{1000\ \mu g}\right)}{AT_{rec}\left(\frac{365\ days}{year} \times LT\ (70\ years)\right)}\right) + \left(\frac{CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1} \times ET_{rec\text{-}c}\left(\frac{hours}{day}\right) \times IRW_{rec\text{-}c}\ \frac{0.12\ L}{hour} \times \left(\frac{mg}{1000\ \mu g}\right)}{BW_{rec\text{-}c}(15\ kg)}\right)}$$

where:

$$IFW_{rec\text{-}adj}\left(\frac{L}{kg}\right) = \left(\frac{EV_{rec\text{-}c}\left(\frac{events}{day}\right) \times ED_{rec\text{-}c}(6\ years) \times EF_{rec\text{-}c}\left(\frac{days}{year}\right) \times ET_{rec\text{-}c}\left(\frac{hours}{event}\right) \times IRW_{rec\text{-}c}\left(\frac{0.12\ L}{hour}\right)}{BW_{recwc}(15\ kg)} + \frac{EV_{rec\text{-}a}\left(\frac{events}{day}\right) \times ED_{rec\text{-}a}(20\ years) \times EF_{rec\text{-}a}\left(\frac{days}{year}\right) \times ET_{rec\text{-}a}\left(\frac{hours}{event}\right) \times IRW_{rec\text{-}a}\left(\frac{0.071\ L}{hour}\right)}{BW_{rec\text{-}a}(80\ kg)}\right)$$

Dermal

$$\text{IF } ET_{event\text{-}rec\text{-}adj}\left(\frac{hours}{event}\right) \le t^*\ (hours), \text{then } SL_{rec\text{-}water\text{-}vc\text{-}der}\ (\mu g/L) = \frac{DA_{event}\left(\frac{ug}{cm^2\text{-}event}\right) \times \left(\frac{1000\ cm^3}{L}\right)}{2 \times FA \times K_p\left(\frac{cm}{hour}\right)\sqrt{\frac{6 \times \tau_{event}\left(\frac{hours}{event}\right) \times ET_{event\text{-}rec\text{-}adj}\left(\frac{hours}{event}\right)}{\pi}}}$$

or,

$$\text{IF } ET_{event\text{-}rec\text{-}adj}\left(\frac{hours}{event}\right) > t^*\ (hours), \text{then } SL_{rec\text{-}water\text{-}vc\text{-}der}\ (\mu g/L) = \frac{DA_{event}\left(\frac{ug}{cm^2\text{-}event}\right) \times \left(\frac{1000\ cm^3}{L}\right)}{FA \times K_p\left(\frac{cm}{hour}\right) \times \left[\frac{ET_{event\text{-}rec\text{-}adj}\left(\frac{hours}{event}\right)}{1+B} + 2 \times \tau_{event}\left(\frac{hours}{event}\right) \times \left(\frac{1+3B+3B^2}{(1+B)^2}\right)\right]}$$

where:

$$DA_{event}\left(\frac{ug}{cm^2\text{-}event}\right) = \frac{TR}{\left(\frac{\left(\frac{CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1}}{GIABS}\right) \times DFW_{rec\text{-}adj}\left(\frac{events\text{-}cm^2}{kg}\right)}{AT_{rec}\left(\frac{365\ days}{year} \times LT\ (70\ years)\right) \times \left(\frac{1000\ \mu g}{mg}\right)}\right) + \left(\frac{\left(\frac{CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1}}{GIABS}\right) \times EV_{rec\text{-}c}\left(\frac{events}{day}\right) \times SA_{rec\text{-}c}\left(6365\ cm^2\right)}{BW_{rec\text{-}c}\ (15\ kg) \times \left(\frac{1000\ \mu g}{mg}\right)}\right)}$$

where:

$$DFW_{rec\text{-}adj}\left(\frac{events\text{-}cm^2}{kg}\right) = \left(\begin{array}{c}\frac{EV_{rec\text{-}c}\left(\frac{events}{day}\right) \times ED_{rec\text{-}c}\ (6\ years) \times EF_{rec\text{-}c}\left(\frac{days}{year}\right) \times SA_{rec\text{-}c}\left(6365\ cm^2\right)}{BW_{rec\text{-}c}\ (15\ kg)} + \\ \frac{EV_{rec\text{-}a}\left(\frac{events}{day}\right) \times ED_{rec\text{-}a}\ (20\ years) \times EF_{rec\text{-}a}\left(\frac{days}{year}\right) \times SA_{rec\text{-}a}\left(19652\ cm^2\right)}{BW_{rec\text{-}a}\ (80\ kg)}\end{array}\right)$$

and:

$$ET_{event\text{-}rec\text{-}adj}\left(\frac{hours}{event}\right) = \left(\frac{\left(ET_{event\text{-}rec\text{-}c}\left(\frac{hours}{event}\right) \times ED_{rec\text{-}c}\ (6\ years)\right) + \left(ET_{event\text{-}rec\text{-}a}\left(\frac{hours}{event}\right) \times ED_{rec\text{-}a}\ (20\ years)\right)}{ED_{rec\text{-}c}\ (6\ years) + ED_{rec\text{-}a}\ (20\ years)}\right)$$

Trichloroethylene

Ingestion

$$SL_{rec\text{-}water\text{-}tce\text{-}ing}\left(\mu g/L\right)=\frac{TR\times AT_{rec}\left(\frac{365\ days}{year}\times LT\left(70\ years\right)\right)\times\left(\frac{1000\ \mu g}{mg}\right)}{CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1}\times RBA\times\left(\left(CAF_o\left(0.804\right)\times IFW_{rec\text{-}adj}\left(\frac{L}{kg}\right)\right)\right)+\left(MAF_o\left(0.202\right)\times IFWM_{rec\text{-}adj}\left(\frac{L}{kg}\right)\right)}$$

where:

$$IFW_{rec\text{-}adj}\left(\frac{L}{kg}\right)=\left(\begin{array}{c}\frac{EV_{rec\text{-}c}\left(\frac{events}{day}\right)\times ED_{rec\text{-}c}\left(6\ years\right)\times EF_{rec\text{-}c}\left(\frac{days}{year}\right)\times ET_{rec\text{-}c}\left(\frac{hours}{event}\right)\times IRW_{rec\text{-}c}\left(\frac{0.12\ L}{hour}\right)}{BW_{rec\text{-}c}\left(15\ kg\right)}+\\ \frac{EV_{rec\text{-}a}\left(\frac{events}{day}\right)\times ED_{rec\text{-}a}\left(20\ years\right)\times EF_{rec\text{-}a}\left(\frac{days}{year}\right)\times ET_{rec\text{-}a}\left(\frac{hours}{event}\right)\times IRW_{rec\text{-}a}\left(\frac{0.071\ L}{hour}\right)}{BW_{rec\text{-}a}\left(80\ kg\right)}\end{array}\right)$$

where:

$$IFWM_{rec\text{-}adj}\left(\frac{L}{kg}\right)=\left(\begin{array}{c}\frac{ED_{0\text{-}2}\left(2\ years\right)\times EF_{0\text{-}2}\left(\frac{days}{year}\right)\times IRW_{0\text{-}2}\left(\frac{0.12\ L}{hour}\right)\times EV_{0\text{-}2}\left(\frac{events}{day}\right)\times ET_{0\text{-}2}\left(\frac{hours}{event}\right)\times 10}{BW_{0\text{-}2}\left(15\ kg\right)}+\\ \frac{ED_{2\text{-}6}\left(4\ years\right)\times EF_{2\text{-}6}\left(\frac{days}{year}\right)\times IRW_{2\text{-}6}\left(\frac{0.12\ L}{hour}\right)\times EV_{2\text{-}6}\left(\frac{events}{day}\right)\times ET_{2\text{-}6}\left(\frac{hours}{event}\right)\times 3}{BW_{2\text{-}6}\left(15\ kg\right)}+\\ \frac{ED_{6\text{-}16}\left(10\ years\right)\times EF_{6\text{-}16}\left(\frac{days}{year}\right)\times IRW_{6\text{-}16}\left(\frac{0.071\ L}{hour}\right)\times EV_{6\text{-}16}\left(\frac{events}{day}\right)\times ET_{6\text{-}16}\left(\frac{hours}{event}\right)\times 3}{BW_{6\text{-}16}\left(80\ kg\right)}+\\ \frac{ED_{16\text{-}26}\left(10\ years\right)\times EF_{16\text{-}26}\left(\frac{days}{year}\right)\times IRW_{16\text{-}26}\left(\frac{0.071\ L}{hour}\right)\times EV_{16\text{-}26}\left(\frac{events}{day}\right)\times ET_{16\text{-}26}\left(\frac{hours}{event}\right)\times 1}{BW_{16\text{-}26}\left(80\ kg\right)}\end{array}\right)$$

Dermal

$$\text{IF } ET_{event\text{-}rec\text{-}madj}\left(\frac{1\ hour}{event}\right) \le t^{*}\ (hours)\ \text{then } SL_{rec\text{-}water\text{-}tce\text{-}der}\,(\mu g/L) = \frac{DA_{tce\text{-}event}\left(\frac{ug}{cm^{2}\text{-}event}\right)\times\left(\frac{1000\ cm^{3}}{L}\right)}{2\times FA\times K_{p}\left(\frac{cm}{hour}\right)\sqrt{\frac{6\times\tau_{event}\left(\frac{hours}{event}\right)\times ET_{event\text{-}rec\text{-}madj}\left(\frac{hours}{event}\right)}{\pi}}}$$

or,

$$\text{IF } ET_{event\text{-}rec\text{-}madj}\left(\frac{hours}{event}\right) > t^{*}\ (hours)\ \text{then } PRG_{rec\text{-}water\text{-}tce\text{-}der}\,(\mu g/L) = \frac{DA_{tce\text{-}event}\left(\frac{ug}{cm^{2}\text{-}event}\right)\times\left(\frac{1000\ cm^{3}}{L}\right)}{FA\times K_{p}\left(\frac{cm}{hour}\right)\times\left[\frac{ET_{event\text{-}rec\text{-}madj}\left(\frac{hours}{event}\right)}{1+B}+2\times\tau_{event}\left(\frac{hours}{event}\right)\times\left(\frac{1+3B+3B^{2}}{(1+B)^{2}}\right)\right]}$$

where:

$$DA_{tce\text{-}event}\left(\frac{ug}{cm^{2}\text{-}event}\right) = \frac{TR\times AT_{rec}\left(\frac{365\ days}{year}\times LT\ (70\ years)\right)\times\left(\frac{1000\ \mu g}{mg}\right)}{\frac{CSF_{o}\left(\frac{mg}{kg\text{-}day}\right)^{-1}}{GIABS}\times\left(\left(AF_{o}\ (0.804)\ \times DFW_{rec\text{-}adj}\left(\frac{events\ \text{-}\ cm^{2}}{kg}\right)\right)+\left(MAF_{o}\ (0.202)\ \times DFWM_{rec\text{-}adj}\left(\frac{events\ \text{-}\ cm^{2}}{kg}\right)\right)\right)}$$

where:

$$DFW_{rec\text{-}adj}\left(\frac{events\ \text{-}\ cm^{2}}{kg}\right) = \left(\frac{EV_{rec\text{-}c}\left(\frac{events}{day}\right)\times ED_{rec\text{-}c}\ (6\ years)\ \times EF_{rec\text{-}c}\left(\frac{days}{year}\right)\times SA_{rec\text{-}c}\left(6365\ cm^{2}\right)}{BW_{rec\text{-}c}\ (15\ kg)}+\frac{EV_{rec\text{-}a}\left(\frac{events}{day}\right)\times ED_{rec\text{-}a}\ (20\ years)\ \times EF_{rec\text{-}a}\left(\frac{days}{year}\right)\times SA_{rec\text{-}a}\left(19652\ cm^{2}\right)}{BW_{rec\text{-}a}\ (80\ kg)}\right)$$

where:

$$DFWM_{rec\text{-}adj}\left(\frac{events\ \text{-}\ cm^{2}}{kg}\right) = \left[\left(\frac{EV_{0\text{-}2}\left(\frac{events}{day}\right)\times ED_{0\text{-}2}\ (2\ years)\ \times EF_{0\text{-}2}\left(\frac{days}{year}\right)\times SA_{0\text{-}2}\left(6365\ cm^{2}\right)\times 10}{BW_{0\text{-}2}\ (15\ kg)}\right)+\left(\frac{EV_{2\text{-}6}\left(\frac{events}{day}\right)\times ED_{2\text{-}6}\ (4\ years)\ \times EF_{2\text{-}6}\left(\frac{days}{year}\right)\times SA_{2\text{-}6}\left(6365\ cm^{2}\right)\times 3}{BW_{2\text{-}6}\ (15\ kg)}\right)+\left(\frac{EV_{6\text{-}16}\left(\frac{events}{day}\right)\times ED_{6\text{-}16}\ (10\ years)\ \times EF_{6\text{-}16}\left(\frac{days}{year}\right)\times SA_{6\text{-}16}\left(19652\ cm^{2}\right)\times 3}{BW_{6\text{-}16}\ (80\ kg)}\right)+\left(\frac{EV_{16\text{-}26}\left(\frac{events}{day}\right)\times ED_{16\text{-}26}\ (10\ years)\ \times EF_{16\text{-}26}\left(\frac{days}{year}\right)\times SA_{16\text{-}26}\left(19652\ cm^{2}\right)\times 1}{BW_{16\text{-}26}\ (80\ kg)}\right)\right]$$

and:

$$ET_{event\text{-}recw\text{-}madj}\left(\frac{hours}{event}\right) = \frac{\left(\begin{array}{l} ET_{event\text{-}rec\,(0\text{-}2)}\left(\frac{hours}{event}\right)\times ED_{0\text{-}2}\ (2\ years)+ET_{event\text{-}rec\,(2\text{-}6)}\left(\frac{hours}{event}\right)\times ED_{2\text{-}6}\ (4\ years)+ \\ ET_{event\text{-}rec\,(6\text{-}16)}\left(\frac{hours}{event}\right)\times ED_{6\text{-}16}\ (10\ years)+ET_{event\text{-}rec\,(16\text{-}26)}\left(\frac{hours}{event}\right)\times ED_{16\text{-}26}\ (10\ years) \end{array}\right)}{ED_{0\text{-}2}\ (2\ years)\ +ED_{2\text{-}6}\ (4\ years)\ +ED_{6\text{-}16}\ (10\ years)\ +ED_{16\text{-}26}\ (10\ years)}$$

A1.5 Trespasser

The trespasser soil, sediment, and surface water scenarios are calculated using the recreator soil, sediment, and surface water equations in section A1.4 with the following trespasser exposure defaults.

Table A1.5-1 Trespasser Exposure Parameters

Symbol	Description	Value	Units	Source
AF0-02	Soil Adherence Factor - age segment 0-2	0.2	(mg/cm2)	EPA
AF02-06	Soil Adherence Factor - age segment 2-6	0.2	(mg/cm2)	EPA
AF06-16	Soil Adherence Factor - age segment 6-16	0.07	(mg/cm2)	EPA
AF16-26	Soil Adherence Factor - age segment 16-26	0.07	(mg/cm2)	EPA
AFsed0-02	Recreator/Trepasser Sediment Adherence Factor - age segment 0-2 - Virginia DEQ	0.3	(mg/cm2)	DEQ
AFsed02-06	Recreator/Trepasser Sediment Adherence Factor - age segment 2-6 - Virginia DEQ	0.3	(mg/cm2)	DEQ
AFsed06-16	Recreator/Trepasser Sediment Adherence Factor - age segment 6-16 - Virginia DEQ	0.2	(mg/cm2)	DEQ
AFsed16-26	Recreator/Trepasser Sediment Adherence Factor - age segment 16-26 - Virginia DEQ	0.2	(mg/cm2)	DEQ
AFtrs-a	Trespasser Soil Adherence Factor- adult	0.07	(mg/cm2)	EPA
AFtrs-c	Trespasser Soil Adherence Factor - child	0.2	(mg/cm2)	EPA
AFtrs-sed-a	Trespasser Sediment Adherence Factor - adult - Virginia DEQ	0.2	(mg/cm2)	DEQ
AFtrs-sed-c	Trespasser Sediment Adherence Factor - child - Virginia DEQ	0.3	(mg/cm2)	DEQ
ATtrs	Trespasser Averaging Time	365	(days/yr)	EPA
ATtrs	Trespasser Averaging Time: 365 x LT	25550	(days)	EPA
ATtrs-a	Trespasser Averaging Time - adult: 365 x EDtrs-a	7300	(days)	EPA
ATtrs-c	Trespasser Averaging Time - child: 365 x EDtrs-c	2190	(days)	EPA
BW0-02	Body Weight - age segment 0-2	15	(kg)	EPA
BW02-06	Body Weight - age segment 2-6	15	(kg)	EPA
BW06-16	Body Weight - age segment 6-16	80	(kg)	EPA
BW16-26	Body Weight - age segment 16-26	80	(kg)	EPA

Symbol	Description	Value	Units	Source
BWtrs-a	Trespasser Body Weight - adult	80	(kg)	EPA
BWtrs-c	Trespasser Body Weight - child	15	(kg)	EPA
DFSMtrs-adj	Trespasser Soil Mutagenic Dermal Contact Factor - age adjusted - Virginia DEQ calculated using age-segment values	29366.4	(mg/kg)	DEQ
DFSMtrs-sed-adj	Trespasser Sediment Mutagenic Dermal Contact Factor - age adjusted - Virginia DEQ calculated using age-segment values	50926.08	(mg/kg)	DEQ
DFStrs-adj	Trespasser Soil Dermal Contact Factor - age adjusted - Virginia DEQ calculated using age-segment values	7089.6	(mg/kg)	DEQ
DFStrs-sed-adj	Trespasser Sediment Dermal Contact Factor - age adjusted - Virginia DEQ calculated using age-segment values	14072.64	(mg/kg)	DEQ
DFWMtrs-adj	Trespasser Surface Water Mutagenic Dermal Contact Factor - age adjusted - Virginia DEQ calculated using age-segment values	561712	(cm2-event/kg)	DEQ
DFWtrs-adj	Trespasser Surface Water Dermal Contact Factor - age adjusted - Virginia DEQ calculated using age-segment values	179016	(cm2-event/kg)	DEQ
ED0-02	Exposure Duration - age segment 0-2	2	(yrs)	EPA
ED02-06	Exposure Duration - age segment 2-6	4	(yrs)	EPA
ED06-16	Exposure Duration -age segment 6-16	10	(yrs)	EPA
ED16-26	Exposure Duration -age segment 16-26	10	(yrs)	EPA
EDtrs	Trespasser Soil/Sediment Exposure Duration	26	(yrs)	EPA
EDtrs-a	Trespasser Soil/Sediment Exposure Duration - adult	20	(yrs)	EPA
EDtrs-c	Trespasser Soil/Sediment Exposure Duration - child	6	(yrs)	EPA
EFtrs	Trespasser Exposure Frequency - Virginia DEQ	24	(days/yr)	DEQ
EFtrs0-02	Trespasser Exposure Frequency - age segment 0-2 - Virginia DEQ	24	(days/yr)	DEQ

Symbol	Description	Value	Units	Source
EFtrs02-06	Trespasser Exposure Frequency - age segment 2-6 - Virginia DEQ	24	(days/yr)	DEQ
EFtrs06-16	Trespasser Exposure Frequency - age segment 6-16 - Virginia DEQ	24	(days/yr)	DEQ
EFtrs16-26	Trespasser Exposure Frequency - age segment 16-26 - Virginia DEQ	24	(days/yr)	DEQ
EFtrs-a	Trespasser Exposure Frequency - adult - Virginia DEQ	24	(days/yr)	DEQ
EFtrs-c	Trespasser Exposure Frequency - child - Virginia DEQ	24	(days/yr)	DEQ
ETevent-rec/trs(0-02)	Recreator/Trespasser Exposure Time - age segment 0-2 - Virginia DEQ	2	(hrs/event)	DEQ
ETevent-rec/trs(02-06)	Recreator/Trespasser Exposure Time - age segment 2-6 - Virginia DEQ	2	(hrs/event)	DEQ
ETevent-rec/trs(06-16)	Recreator/Trespasser Exposure Time - age segment 6-16 - Virginia DEQ	2	(hrs/event)	DEQ
ETevent-rec/trs(16-26)	Recreator/Trespasser Exposure Time - age segment 16-26 - Virginia DEQ	2	(hrs/event)	DEQ
ETevent-trs-a	Trespasser Surface Water Exposure Time - adult - Virginia DEQ	2	(hrs/event)	DEQ
ETevent-trs-adj	Trespasser Exposure Time - age adjusted - Virginia DEQ calculated using age-segment values	2	(hrs/event)	DEQ
ETevent-trs-c	Trespasser Surface Water Exposure Time - child - Virginia DEQ	2	(hrs/event)	DEQ
ETevent-trs-madj	Trespasser Exposure Time - mutagen age adjusted - Virginia DEQ calculated using age-segment values	2	(hrs/event)	DEQ
ETrec/trs0-02	Recreator/Trespasser Exposure Time - age segment 0-2 - Virginia DEQ	2	(hrs/day)	DEQ
ETrec/trs02-06	Recreator/Trespasser Exposure Time - age segment 2-6 - Virginia DEQ	2	(hrs/day)	DEQ

Symbol	Description	Value	Units	Source
ETrec/trs06-16	Recreator/Trespasser Exposure Time - age segment 6-16 - Virginia DEQ	2	(hrs/day)	DEQ
ETrec/trs16-26	Recreator/Trespasser Exposure Time - age segment 16-26 - Virginia DEQ	2	(hrs/day)	DEQ
ETtrs	Trespasser Soil Exposure Time - Virginia DEQ	2	(hrs/day)	DEQ
ETtrs-a	Trespasser Exposure Time - adult - Virginia DEQ	2	(hrs/day)	DEQ
ETtrs-c	Trespasser Exposure Time - child - Virginia DEQ	2	(hrs/day)	DEQ
ETtrs-sed	Trespasser Sediment Exposure Time - Virginia DEQ	2	(hrs)	DEQ
EV0-02	Events - age segment 0-2	1	(events/day)	DEQ
EV02-06	Events - age segment 2-6	1	(events/day)	DEQ
EV06-16	Events - age segment 6-16	1	(events/day)	DEQ
EV16-26	Events - age segment 16-26	1	(events/day)	DEQ
EVtrs-a	Trespasser Events - adult - Virginia DEQ	1	(events/day)	EPA
EVtrs-c	Trespasser Surface Water Events - child - Virginia DEQ	1	(events/day)	DEQ
IFMtrs-sed-adj	Trespasser Mutagenic Sediment Ingestion Rate - age adjusted - Virginia DEQ calculated using age-segment values	11440	(mg/kg)	DEQ
IFSMtrs-adj	Trespasser Mutagenic Soil Ingestion Rate - age adjusted - Virginia DEQ calculated using age-segment values	11440	(mg/kg)	DEQ
IFStrs-adj	Trespasser Soil Ingestion Rate - age adjusted - Virginia DEQ calculated using age-segment values	2520	(mg/kg)	DEQ
IFStrs-sed-adj	Trespasser Sediment Ingestion Rate - age adjusted - Virginia DEQ calculated using age-segment values	2520	(mg/kg)	DEQ

Symbol	Description	Value	Units	Source
IFWMtrs-adj	Trespasser Mutagenic Surface Water Ingestion Rate - age adjusted - Virginia DEQ calculated using age-segment values	15.111	(L/kg)	DEQ
IFWtrs-adj	Trespasser Surface Water Ingestion Rate - age adjusted - Virginia DEQ calculated using age-segment values	3.624	(L/kg)	DEQ
INHMtrs-sed-adj	Trespasser Sediment Inhalation Exposure Duration Mutagen - age adjusted - Virginia DEQ calculated using age-segment values	144	(days)	DEQ
INHMtrs-soil-adj	Trespasser Soil Inhalation Exposure Duration Mutagen - age adjusted - Virginia DEQ calculated using age-segment values	144	(days)	DEQ
IRS0-02	Soil/Sediment Ingestion Rate - age segment 0-2	200	(mg/day)	EPA
IRS02-06	Soil/Sediment Ingestion Rate - age segment 2-6	200	(mg/day)	EPA
IRS06-16	Soil/Sediment Ingestion Rate - age segment 6-16	100	(mg/day)	EPA
IRS16-26	Soil/Sediment Ingestion Rate - age segment 16-26	100	(mg/day)	EPA
IRStrs-a	Trespasser Soil Ingestion Rate - adult	100	(mg/day)	EPA
IRStrs-c	Trespasser Soil Ingestion Rate - child	200	(mg/day)	EPA
IRtrs-sed-a	Trespasser Sediment Ingestion Rate - adult	100	(mg/day)	EPA
IRtrs-sed-c	Trespasser Sediment Ingestion Rate - child	200	(mg/day)	EPA
IRW0-02	Surface Water Ingestion Rate - age segment 0-2	0.12	(L/hr)	EPA
IRW02-06	Surface Water Ingestion Rate - age segment 2-6	0.12	(L/hr)	EPA
IRW06-16	Surface Water Ingestion Rate - age segment 6-16	0.124	(L/hr)	EPA
IRW16-26	Surface Water Ingestion Rate - age segment 16-26	0.0985	(L/hr)	EPA
IRWtrs-a	Trespasser Surface Water Ingestion Rate - adult	0.11	(L/hr)	EPA
IRWtrs-c	Trespasser Surface Water Ingestion Rate - child	0.12	(L/hr)	EPA
SAs0-02	Surface Area Soil/Sediment - age segment 0-2	2373	(cm2/day)	EPA
SAs02-06	Surface Area Soil/Sediment - age segment 2-6	2373	(cm2/day)	EPA

Symbol	Description	Value	Units	Source
SAs06-16	Surface Area Soil/Sediment - age segment 6-16	6032	(cm2/day)	EPA
SAs16-26	Surface Area Soil/Sediment - age segment 16-26	6032	(cm2/day)	EPA
SAtrs-a	Trespasser Soil Surface Area - adult	6032	(cm2/day)	EPA
SAtrs-a	Trespasser Surface Water Surface Area Surface - adult	19652	(cm2)	EPA
SAtrs-c	Trespasser Surface Water Surface Area - child	6365	(cm2)	EPA
SAtrs-c	Trespasser Soil Surface Area - child	2373	(cm2/day)	EPA
SAtrs-sed-a	Trespasser Sediment Surface Area - adult	6032	(cm2/day)	EPA
SAtrs-sed-c	Trespasser Sediment Surface Area - child	2373	(cm2/day)	EPA
SAw0-02	Surface Area Water - age segment 0-2	6365	(cm2)	EPA
SAw02-06	Surface Area Water - age segment 2-6	6365	(cm2)	EPA
SAw06-16	Surface Area Water - age segment 6- 16	19652	(cm2)	EPA
SAw16-26	Surface Area Water - age segment 16- 26	19652	(cm2)	EPA

A1.6 Vapor Intrusion (VI) Equation

Vapor Intrusion (VI) evaluation relies on multiple lines of evidence. Soil gas screening values are calculated by dividing the indoor air screening level by an attenuation factor of 0.03 (unitless) for shallow/sub-slab soil gas, and 0.01 for deep soil gas. Sub-slab/shallow soil gas concentration units are $\mu g/m^3$. These values are valid only for the screening levels module. VURAM's quantitative hazard/risk calculations are based on contaminant concentrations in indoor air. The construction worker scenario follows appendix A2.0 calculations for groundwater inhalation and trench soil gas. Screening levels for groundwater VI are developed as calculated below. Groundwater VI screening levels for both residential and industrial receptors are computed for the groundwater medium, **NOT** the air medium. Screening level units are µg/L.

$$SL_{gw} = SL_{target,\ ia} / (HLC \times AF_{gw} \times cf) \quad \mu g/L$$

Where:

SL_{gw}	=	screening level for groundwater	µg/L
$SL_{target,\ ia}$	=	chemical-specific indoor air screening value	$\mu g/m^3$
AF_{gw}	=	0.001 groundwater attenuation factor	unitless
HLC	=	dimensionless Henry's Law Constant at specified groundwater temperature	Unitless
cf	=	1000 conversion factor	L/m^3

A1.7 Soil Screening Level (SSL) Groundwater Dilution Attenuation Factor (DAF) Equations

The SSL for groundwater is computed using a DAF value multiplied by the chemical specific target concentration equation. For the risk-based SSL, the groundwater (residential tapwater) screening level is used. For the MCL-based SSL, the MCL value is used. The soil-water partition equation for the migration to groundwater depends on whether the chemical is organic or inorganic. Under RCRA corrective action, screening is DAF-1, or $C_t \times 1 = C_t$. For VRP, the SSL is DAF-20, calculated as $C_t \times 20$. DAF equations are from Soil Screening Guidance Technical Background Document Part 2 (EPA, 1996a).

$$\text{Inorganic } C_t = C_w \{ K_d + [(\Theta_w + \Theta_a H') / \rho_b] \} \quad mg/kg$$

$$\text{Organic } C_t = C_w \{ (K_{oc} f_{oc}) + [(\Theta_w + \Theta_a H') / \rho_b] \} \quad mg/kg$$

Where:

C_t	=	screening level in soil SSL DAF	mg/kg
C_w	=	target groundwater (soil leachate) concentration	µg/L
K_d	=	chemicalspecific soil-water partition coefficient	L/kg
Θ_w	=	0.3 (30%) water-filled soil porosity	unitless
Θ_a	=	0.13 air-filled soil porosity	unitless
H'	=	chemical-specific dimensionless Henry's law constant	unitless
K_{oc}	=	chemical-specific soil organic carbon-water partition coefficient	L/kg
f_{oc}	=	0.002 (0.2%) organic carbon content of soil	unitless

A1.8 Algebraic Process Example for Solving for Quantitative Hazard/Risk Calculations

Computation of quantitative hazard/risk levels requires solving algebraically for total hazard quotient (THQ)total risk (TR) with chemical concentrations (CON) in place of the screening level term to obtain a hazard quotient/risk level.

The following examples use the residential soil equations for both hazard quotient (noncarcinogenic) child and carcinogenic risk for the ingestion exposure pathway. Numeric values are excluded for mathematical clarity. A complete list of VURAM exposure defaults for each receptor is presented in the tables at the beginning of each receptor section in this appendix.

EPA RSL User's Guide provides the equation for calculating screening level in the following format:

$$SLres - soil - nc - ingc = \frac{THQ \times ATressc \times EDresc \times BWressc}{EFressc \times EDressc \times \frac{RBA}{RfDo} \times IRSressc \times 10^{-6}}$$

The hazard quotient (HQ) is obtainted by algebraic rearrangement to solve for THQ where the SL term is reassigned as concentration (CON):

$$HQres - soil - nc - ingc = CON \times \frac{EFressc \times EDressc \times \frac{RBA}{RfD} \times IRSressc \times 10^{-6}}{ATressc \times EDressc \times BWressc}$$

EPA RSL User's Guide provides the equation for calculating the screening level in the following format:

$$SLres - soil - c - ing = \frac{TR \times ATress \times LT}{CSFo \times RBA \times IFSres - adj \times 10^{-6}}$$

Risk level is calculated in the following formula by solving for TR where the SL term is reassigned as concentration (CON):

$$Riskres - soil - c - ing = CON \times \frac{CSFo \times RBA \times IFSres - adj \times 10^{-6}}{ATress \times LT}$$

A2.0. Construction Worker Trench Model

There are no well-established models available for estimating migration of volatiles from groundwater into a construction/utility trench. Virginia DEQ recommends the following trench model, developed by Virginia DEQ, for evaluating construction groundwater and soil gas. This approach is incorporated into the screening levels module of VURAM and used to calculate hazard/risk values for the construction study area in the quantitive module. As construction workers are presumed to be adults, age-adjusted and mutagenic equations, as well as TCE and VC specific equations, do not apply to the construction worker computations.

Both models are based on a two-step process. First, a simple fate and transport equation of a vadose zone model to estimate volatilization of gases (emission flux of VOCs) from contaminated groundwater into the air of the trench. Then a box model is used to estimate dispersion of the contaminants from the air inside the trench into the above-ground atmosphere to estimate the EPC for air in a construction trench (C_{trench}). For chemicals that are not included in the RSL table, calculate EPCs for air in a construction trench following the soil gas equations. Provide references for all chemical-specific parameters used.

In October 2017, Virginia DEQ revised the parameterization of the soil gas equations underlying the Construction Worker Trench Model. During a review of the equations and approaches utilized in the Virginia DEQ's construction worker trench model, risk assessment staff identified the need for a modification to the soil gas trench model that evaluates risks from soil vapor to construction workers in a trench. Currently, Virginia DEQ's application of the groundwater trench model assumes that the distance from the bottom of the trench to a vapor source is 31 cm. This value is adjusted to 1 cm for the soil gas trench model; this change applies ONLY to the soil gas portion of the trench model. This modification is made because soil gas analytical results are direct measurements of vapors within the soil column that could be directly adjacent to the trench and diffusing directly through the trench walls. It is a reasonable assumption that the contaminated source materials or soil gas would intersect with the trench walls. The change is also consistent with EPA's recent acknowledgment that contaminated groundwater is not the only source of vapor and that soils saturated with volatiles can also be a significant driver of vapor contamination (EPA VI Guidance, HRS Scoring). As a result, there is a substantial change in the construction worker soil gas screening levels. Modifying the model in this way provides a more accurate representation of both exposures and risks to construction workers in these scenarios, and is consistent with other regulatory agencies' approaches and their application of Virginia DEQ's Construction Worker Trench Model.

Virginia DEQ's Construction Worker Trench Model (groundwater) has been adopted by other state agencies because it captures scenarios involving the exposure of a construction worker to vapors from contaminated groundwater. With the 2017 revision of the soil gas portion, the Construction Worker Trench Model also captures scenarios involving exposure to gases directly measured in the trench and incorporates vapor concentrations directly measured in the subsurface. The Virginia DEQ Construction Worker Trench Model (for groundwater and soil gas) was reviewed by Contaminated Sites Approved Professionals of British Columbia (CSAP) Society in October, 2012 (Meridian, 2012).

Table A2.0-1 Trench Exposure Parameters

Symbol	Description	Value	Units	Source
TR-ACH	Trench Air Changes per Hour - Virginia DEQ	2	(h)-1	DEQ
TR-ACvad	Trench Advection Coefficient Groundwater greater than 15ft - Virginia DEQ	0.25	(cm3/cm3)	DEQ
TR-CF1	Trench Conversion Factor-1	0.001	(L/cm3)	DEQ
TR-CF2	Trench Conversion Factor-2	10000	(cm2/m2)	DEQ
TR-CF3	Trench Conversion Factor-3	3600	(s/hr)	DEQ
TR-CF4	Trench Conversion Factor-4	1000000	(cm3/m3)	DEQ
TR-D-dir	Trench Depth - groundwater less Than 15ft - Virginia DEQ	2.44	(m)	DEQ
TR-D-ind	Trench Depth - groundwater greater than 15ft - Virginia DEQ	4.57	(m)	DEQ
TR-Dsg	Trench - Depth to soil gas vapor source - Virginia DEQ	1	(cm)	DEQ
TR-EFcw	Trench Construction Worker Exposure Frequency - Virginia DEQ	125	(days/yr)	DEQ
TR-ETcw	Trench Construction Worker Exposure Time - Virginia DEQ	4	(hrs/day)	DEQ
TR-EVcw	Trench Construction Worker Events - Virginia DEQ	1	(events/day)	DEQ
TR-F	Trench Fraction of floor through which contaminant can enter - Virginia DEQ	1	(unitless)	DEQ
TR-HV	Trench Thickness of Vadose Zone - groundwater greater than 15 ft - Virginia DEQ	30	(cm)	DEQ
TR-IRcw	Trench Construction Worker Groundwater Ingestion Rate - Virginia DEQ	0.02	(L/day)	DEQ
TR-KGH2O	Trench Gas-phase mass transfer coefficient of water vapor at 25deg C - Virginia DEQ	0.833	(cm/s)	DEQ

Symbol	Description	Value	Units	Source
TR-KLO2	Trench Liquid-phase mass transfer coefficient of oxygen at 25deg C - Virginia DEQ	0.002	(cm/s)	DEQ
TR-L	Trench Length - Virginia DEQ	2.44	(m)	DEQ
TR-Lgw	Trench Depth to groundwater - Virginia DEQ	488	(cm)	DEQ
TR-MWH2O	Trench Molecular Weight of Water - Virginia DEQ	18	(unitless)	DEQ
TR-MWO2	Trench Molecular Weight of Oxygen - Virginia DEQ	32	(unitless)	DEQ
TR-Porvad	Trench Porosity in Vadose Zone - groundwater greater than 15ft - Virginia DEQ	0.44	(cm3/cm3)	DEQ
TR-R	Trench Ideal Gas Constant - Virginia DEQ	0.000082	(atm-m3/mol-K)	DEQ
TR-Temp-F	Trench Temperature Fahrenheit - Virginia DEQ	77	(F)	DEQ
TR-Temp-K	Trench Temperature - Virginia DEQ	298	(K)	DEQ
TR-W	Trench Width - Virginia DEQ	0.91	(m)	DEQ
TR-W/D	Trench Width to Depth Ratio - Virginia DEQ	0.38	(unitless)	DEQ

A2.1 Groundwater

Two exposure scenarios are evaluated based on the site-specific depth of the groundwater: indirect contact based on contaminant transport through the vadose zone groundwater depth greater than 15 feet and direct contact based on groundwater pooling in the trench groundwater depth less than or equal to 15 feet. Two unique volatilization factors (VF) are computed for each chemical. For indirect contact, where the groundwater is greater than 15 feet, the VF_{gt} equation (2-2) is used. For direct contact, where the groundwater is less than 15 feet, VF_{lt} equation (2-4) is applied. Virginia DEQ assumes that a construction project could result in an excavation as deep as 15 feet. At some sites there is a high probability that construction projects with deeper excavations may occur. Contact Virginia DEQ project manager and risk assessor to discuss the appropriate assumptions for site-specific parameters.

Equations (2-2) or (2-4) are used to calculate chemical-specific VF_{lt} and VF_{gt}. Residential groundwater equations for noncancer adult and cancer, found in appendix A1.1.2, and construction worker exposure values, are used to compute screening levels or hazard/risk values. The appropriate groundwater VF (VF_{lt} or VF_{gt}) replaces the Andelman Volatilization Factor (K=0.5) in the residential groundwater equations.

Airborne concentration of a contaminant in a trench can be estimated using Equation 2-1:

$$C_{trench} = C_{gw} \times VF \qquad (2\text{-}1)$$

Where:

C_{trench}	=	concentration of contaminant in the trench	µg/m³
C_{gw}	=	concentration of contaminant in groundwater	µg/L
VF	=	volatilization factor see equations 2-2 and 2-4 (chemical-specific)	L/m³

A2.1.1 Groundwater Greater Than 15 Feet Deep

$$VF = (H_i \times D_{air} \times AC_{vad}^{3.33} \times A \times F \times 10^{-3} \times 10^{4} \times 3600) / (R \times T \times L_d \times ACH \times V \times Por_{vad}^{2}) \qquad (2\text{-}2)$$

Where:

H_i	=	Henry's Law constant for contaminant (RSL table)	atm-m³/mol
D_{air}	=	diffusion coefficient in air (RSL table)	cm²/s
AC_{vad}	=	volumetric air content in vadose zone soil	cm³/cm³
A	=	area of trench	m²
F	=	fraction of floor through which contaminant can enter	unitless
R	=	ideal gas constant	atm-m³/mole-K
T	=	average system absolute temperature	K
L_d	=	distance between trench bottom and groundwater equation 2-3	Cm
ACH	=	air changes per hour	h^{-1}
V	=	volume of trench	m³
Por_{vad}	=	total soil porosity in vadose zone	cm³/cm³
10^{-3}	=	conversion factor	L/cm³
10^{4}	=	conversion factor	cm²/m²
3600	=	conversion factor	s/hr

The value for R is 8.2×10^{-5}. A default value of 298K may be used for the average system absolute temperature.

Studies of urban canyons suggest that if the ratio of trench width -- relative to wind direction -- to trench depth is less than or equal to 1, a circulation cell or cells will be set up within the trench that limits the degree of gas exchange with the atmosphere. In consultation with EPA Region III, Virginia DEQ has assumed an ACH in this case of 2/hr -- based upon measured ventilation rates of buildings.

L_d	=	$L_{gw} - D_{trench}$	(2-3)

Where:

L_{gw}	= depth to groundwater	cm
D_{trench}	= depth of trench	cm

A2.1.2 Groundwater Less Than or Equal to 15 Feet Deep

If the depth to groundwater at a site is less than 15 feet, DEQ assumes that a worker would encounter groundwater when digging an excavation or a trench. The worker would then have direct exposure to the groundwater. The worker would also be exposed to contaminants in the air inside the trench that would result from volatilization from the groundwater pooling at the bottom of the trench. Virginia DEQ assumes that the trench would only intercept the groundwater for a few inches since a groundwater pool of more than a few inches would likely require dewatering. Therefore, trench depth should be set to equal the actual depth to groundwater at the site. Equation (2-4) is used to calculate VF_{lt}.

VF	=	$(K_i \times A \times F \times 10^{-3} \times 10^4 \times 3600) / (ACH \times V)$	(2-4)

Where:

K_i	= overall mass transfer coefficient of contaminant equation 2-5	cm/s
A	= area of the trench	m^2
F	= fraction of floor through which contaminant can enter	unitless
ACH	= air changes per hour	h^{-2}
V	= volume of trench	m^3
10^{-3}	= conversion factor	L/cm^3
10^4	= conversion factor	cm^2/m^2
3600	= conversion factor	s/hr

Studies of urban canyons suggest that if the ratio of trench width -- relative to wind direction -- to trench depth is less than or equal to 1, a circulation cell or cells will be set up within the trench that limits the degree of gas exchange with the atmosphere. In consultation with EPA Region III, DEQ has assumed an ACH in this case of 2/hr based upon measured ventilation rates of buildings.

K_i	$= 1 / \{(1 / k_{iL}) + [(R\ T) / (H_i\ k_{iG})]\}$	(2-5)

Where:

k_{iL}	=	liquid-phase mass transfer coefficient of i equation 2-6	cm/s
R	=	ideal gas constant	atm-m^3/mol-K

T	=	average system absolute temperature	K
H_i	=	Henry's Law constant of I	atm-m³/mol
K_{iG}	=	gas-phase mass transfer coefficient of i (Equation 3-7)	cm/s

The value for R is 8.2 x 10^{-5}. A default value of 298K may be used for the average system absolute temperature.

$$k_{iL} = (MW_{O2}/MW_i)^{0.5} \times (T/298) \times k_{L,O2} \qquad (2\text{-}6)$$

Where:

k_{iL}	=	liquid-phase mass transfer coefficient of component i	cm/s
MW_{O2}	=	molecular weight of O_2	g/mol
MW_i	=	molecular weight of component i	g/mol
$k_{L,\,O2}$	=	liquid-phase mass transfer coefficient of oxygen at 25°C	cm/s

The value of k_L, O_2 is 0.002 cm/s.

$$k_{iG} = (MW_{H2O}/MW_i)^{0.335} \times (T/298)^{1.005} \times k_{G,\,H2O} \qquad (2\text{-}7)$$

Where:

k_{iG}	=	gas-phase mass transfer coefficient of component i	cm/s
MW_{H2O}	=	molecular weight of water	g/mol
$k_{G,H2O}$	=	gas-phase mass transfer coefficient of water vapor at 25°C	cm/s

The value of k_G, H_2O is 0.833 cm/s.

(*Superfund Exposure Assessment Manual*, EPA, Office of Remedial Response, April, 1988.)

A2.2 Soil Gas

This model can be used to estimate the contaminant concentration in soil vapor (C_{sv}) partitioning from the groundwater concentration. The contaminant is then transported by diffusion to the trench base or face (where applicable) and diluted by mixing within the trench. In order to accommodate the assumption that the construction worker could intersect with the sample collection depth, distance between the trench bottom and vapor source (L_d) is modified to 1cm.

A unique, chemical-specific, dimensionless volatilization factor for soil vapor (VF_{sv}) is developed based on the groundwater VF_{gt} equation (2-2). Trench dimensions remain consistent with groundwater equations. Apply the construction exposure parameters to the residential air equations for noncancer adult and cancer, found in appendix A1.1.3. The resulting hazard/risk is multiplied by the chemical-specific VF_{sv} as an attenuation factor to obtain a final hazard/risk value. Screening values are likewise computed by using the residential equations and then dividing by VF_{sv}. The final screening value is the lower of the calculated noncancer/cancer screening values.

Soil gas volatilization factor is based on groundwater depth greater than 15 feet, equations (2-1) and (2-2). Combining these two equations yields:

$$C_{trench} = C_{gw} \times (H_i \times D_{air} \times AC_{vad}^{3.33} \times A \times F \times 10^{-3} \times 10^{4} \times 3600) / (R \times T \times L_d \times ACH \times V \times Por_{vad}^{2})$$

Where:

H_i	= Henry's Law constant for contaminant (RSL table)	atm-m³/mol
D_{air}	= diffusion coefficient in air (RSL table)	cm²/s
AC_{vad}	= volumetric air content in vadose zone soil	cm³/cm³
A	= area of trench	m²
F	= fraction of floor through which contaminant can enter	unitless
R	= ideal gas constant	atm-m³/mole-K
T	= average system absolute temperature	K
L_d	= distance between trench bottom and groundwater equation 2-3	cm
ACH	= air changes per hour	h^{-1}
V	= volume of trench	m³
Por_{vad}	= total soil porosity in vadose zone	cm³/cm³
10^{-3}	= conversion factor	L/cm³
10^{4}	= conversion factor	cm²/m²
3600	= conversion factor	s/hr

Soil gas concentrations are estimated from groundwater concentrations using the following equations:

$$C_{sg} = HLC \times C_{gw} \quad (2\text{-}8)$$

$$HLC = Hi / R \times T \quad (2\text{-}9)$$

Where:

C_{sg}	= concentration in soil gas	(µg/m³)
HLC	= dimensionless Henry's Law Constant	(unitless)

Combining equations (2-8) and (2-9) and solving for the groundwater concentration yields:

$$C_{gw} = C_{sg} \times [(R \times T) / H_i] \quad (2\text{-}10)$$

Substituting equation (2-10) in trench concentration equation yields:

$$C_{trench} = C_{sg} \times [(R \times T) / H_i] \times [(H_i \times D_{air} \times AC_{vad}^{3.33} \times A \times F \times 10^{-3} \times 10^4 \times 3600) / (R \times T \times L_d \times ACH \times V \times Por_{vad}^2)] \quad (2\text{-}11)$$

Equation (2-11) simplifies to the following:

$$C_{trench} = C_{sg} \times [(D_{air} \times AC_{vad}^{3.33} \times A \times F \times 10^4 \times 3600) / (L_d \times ACH \times V \times Por_{vad}^2 \times 10^6)] \quad (2\text{-}12)$$

Since the concentation in the trench is equal to the soil gas concentration times VF_{sv}:

$$V_{sv} = (D_{air} \times AC_{vad}^{3.33} \times A \times F \times 10^4 \times 3600) / (L_d \times ACH \times V \times Por_{vad}^2 \times 10^6)] \quad (2\text{-}13)$$

Where:

D_{air}	=	diffusion coefficient in air (RSL table)	cm²/s
AC_{vad}	=	volumetric air content in vadose zone soil	cm³/cm³
A	=	area of trench	m²
F	=	fraction of floor through which contaminant can enter	unitless
L_d	=	distance between trench bottom and groundwater assumed to be 1	cm
ACH	=	air changes per hour	h^{-2}
V	=	volume of trench	m³
Por_{vad}	=	total soil porosity in vadose zone	cm³/cm³
10^6	=	conversion factor	cm³/m³
10^4	=	conversion factor	cm²/m²
3600	=	conversion factor	s/hr

A3.0 Chemical Notes

Several chemicals have special circumstances for calculation in screening, quantitative risk assessment, or both. The following notes are repeated throughout this User Guide in the relevant content sections. They are compiled here for quick reference.

A3.1 Trihalomethanes (THMs) and Haloacetic Acids (HAAs)

The individual trihalomethanes (bromodichloromethane; bromoform; dibromochloromethane, chloroform) all have the MCL of 80 µg/L listed in the RSL table. However, 80 µg/L is the MCL for Total Trihalomethanes. The individual haloacetic acids (dichloroacetic acid, trichloroacetic acid, chloroacetic acid, bromoacetic acid, and dibromoacetic acid) all have the MCL of 60 µg/L listed in the RSL table. However, 60 µg/L is the MCL for Total haloacetic acids.

These MCL are based on the ability of public water suppliers or treatment systems to maintain certain chlorine levels to control bacteria and other pathogens. Virginia DEQ current policy allows for the use of MCLs as the final acceptable value for closures and as GPS. Facilities may be allowed to use the MCL for total THMs or total HAAs, provided that the sum of detected concentrations and the detection limits (for non detects) is below the MCL value of 80 µg/L or 60 µg/L respectively.

A3.2 Lead

VURAM's quantitative risk assessment module does **NOT** perform an evaluation for lead exposure. However, VURAM does include lead in the screening for soil and groundwater.

The current RSL screening value for lead in soils is 400 mg/kg for residential and 800 mg/kg for industrial. Lead does not have an MCL; however, EPA assigns an action level based on treatment technology, which serves as an MCL for screening. This action level is propagated to the residential tapwater screening level for lead uin RSL. The screening value for lead in soil under VRP is the SSL-DAF 20 value.

A3.3 Refractory Ceramic Fibers and Asbestos

The ATSDR chronic RfC for refractory ceramic fibers is presented in units of fibers/cm^3 (0.03 fibers/cm^3). The RfC presented in the RSL tables and calculator is converted to units of fibers/m^3 (3E+04 fibers/m^3), to be consistent with all other chemicals where the RfC unit is mg/m^3. When the chronic RfC is used in the standard RSL air inhalation equations, the resulting units are not in µg/m^3 like all the other chemicals, rather the units are in fibers/m^3. RSLs are only calculated for air as the medium. The air values in the RSL table are calculated using the equations provided in equations for residential and industrial receptors. The units for the MCL for asbestos are in fibers/L.

A3.4 Mercury Inhalation

The inhalation pathway and VI scenarios for mercury use screening levels for elemental mercury, CAS 7439-97-6.

A3.5 Chome

In the absence of speciation data, assume that all chromium concentrations are in the hexavalent form, chromium VI, CAS 18540-29-9.

A3.6 Methyl Mercury

For surface water screening methyl mercury, CAS 22967-92-6, concentrations are in mg/kg instead of µg/L. This fish tissue residue criterion for methylmercury is based on a total fish consumption rate of 0.0175 kg/day.

A3.7 Proxy Chemicals

VURAM includes proxy values for some chemicals with similar toxicity properties. These values are not applied to surface water screening. However, in accordance with the human health criteria table, the screening value for PCBs is applied to all PCBs (i.e., the sum of all congeners or all isomers or homologs or aroclors). For surface water screening under both RCRA and VRP, both EPA and Virginia water quality criteria are used. Refer to section 2.5.1 for screening criteria.

The proxy chemicals list was developed using "Langley Air Force Base Remedial Investigation Report for IRP Sites LF-01, LF-05, LF-15, LF-18, LF-22, and FT-41, Radian, November 1998." Proxy chemicals update cemical-specific values to selected target chemicals. All screening values and toxicity values are included in the proxy chemical update. Chemical properties are **NOT** updated as proxy values. As a result, hazard/risk values are not computed for target chemicals unless all necessary chemical properties are available. Screening values are directly populated by proxy.

Table 3.1-1 Proxy Chemical Updates

Target Chemical	Target CAS	Proxy Chemical	Proxy CAS
trans-1,3-Dichloropropene	10061-02-6	1,3-Dichloropropene	542-75-6
cis-1,3-Dichloropropene	10061-01-5	1,3-Dichloropropene	542-75-6
1,3-Dichlorobenzene (meta)	541-73-1	1,4-dichlorobenzene	106-46-7
delta-BHC	319-86-8	alpha-BHC (Hexachlorocyclohexane, Alpha-)	319-84-6
alpha-Chlordane	5103-71-9	Chlordane	12789-03-6
gamma-Chlordane	5103-74-2	Chlordane	12789-03-6
Endosulfan II	33213-65-9	Endosulfan	115-29-7
Endosulfan I	959-98-8	Endosulfan	115-29-7
Endrin Ketone	53494-70-5	Endrin	72-20-8
Endrin Aldehyde	7421-93-4	Endrin	72-20-8
Isopropyltoluene	99-87-6	Isopropylbenzene (cumene)	98-82-8
Total PCBs	1336-36-3Total	Polychlorinated Biphenyls (high risk)	1336-36-3-Hi
Aroclor-1268	11100-14-4	Polychlorinated Biphenyls (high risk)	1336-36-3-Hi
Aroclor-1262	37324-23-5	Polychlorinated Biphenyls (high risk)	1336-36-3-Hi
Phenanthrene	85-01-8	Pyrene	129-00-0
Acenaphthylene	208-96-8	Pyrene	129-00-0
Benzo(g,h,i)perylene	191-24-2	Pyrene	129-00-0

A3.8 Chemical Abstract Service Registration Number (CAS RN) Substitutes

Beginning in June 2017, the EPA began issuing an identification number for some RSL analytes which had previously been assigned a CAS value of “na”. This E# can be found at the Substance Registry Service (SRS). CAS RN and EPA Identification numbers are used wherever available. For chemicals that have no CAS RN, or have a duplicate CAS RN with distinct chemical properties, an unofficial value is assigned in the CAS column of VURAM (e.g., cadmium, which has different properties in soil than water).

Table 3.2-1 EPA Identification Number CAS RN Substitutions

Analyte	CAS No
Dinitrotoluene Mixture, 2,4/2,6-	E1615210
Diesel Engine Exhaust	E17136615
JP-7	E1737665
Dibutyltin Compounds	E1790660
Thiocyanates	E1790664
Total Petroleum Hydrocarbons (Aliphatic Low)	E1790666
Total Petroleum Hydrocarbons (Aliphatic Medium)	E1790668
Total Petroleum Hydrocarbons (Aliphatic High)	E1790670
Total Petroleum Hydrocarbons (Aromatic Low)	E1790672
Total Petroleum Hydrocarbons (Aromatic Medium)	E1790674

Analyte	CAS No
Total Petroleum Hydrocarbons (Aromatic High)	E1790676
Tributyltin Compounds	E1790678
Toxaphene, Weathered	E1841606
Coke Oven Emissions	E649830
Nitrate + Nitrite (measured as nitrogen)	E701177
Chloramines, Organic	E701235
Nickel Refinery Dust	E715532
Refractory Ceramic Fibers (units in fibers)	E715557

Table A3.2-2 DEQ CAS RN Substitutions

Analyte	CAS
Polychlorinated Biphenyls (high risk)	1336-36-3-Hi
Polychlorinated Biphenyls (low risk)	1336-36-3-Low
Polychlorinated Biphenyls (lowest risk)	1336-36-3-Lowest
Total PCBs	1336-36-3Total
2,3,4,6-tetrachlorophenol, sodium salt	255675-5-9
Manganese (Diet)	7439-96-5-Diet
Manganese (Non-diet)	7439-96-5-NonDiet
Cadmium (Diet)	7440-43-9-Diet
Cadmium (Water)	7440-43-9-Water
Creosote	Creosote
Endrin metabolites	Endrin-Metab
Ethylenebisdithiocarbamic acid, salts and esters	Etybisdithiocarb-salts
Hexane, Commercial	HEX-Comm
Heptochlorodibenzofurans	Hexdibenzfur
Heptachlorodibenzo-p-dioxins	Hexdibenz-p-diox
Nicotine salts	Nico-salt
Nitrogen mustard, hydrochloride salt	Nmust-HCl-salt
Nitrogen mustard, N-oxide, hydrochloride salt	Nmust-Nox-HCl-salt
Pentachlorodibenzofurans	Pentchlordibenzfur
Phthalic acid esters, N.O.S.	Phth-Acd-Estr
Polychlorinated dibenzo-p-dioxins; PCDD's	Polychlordibenz-p-diox
Saccharin salts	Sacch-salts
Tetrachlorodibenzofurans	Tetchldibenzfur
Tetrachlorodibenzo-p-dioxins	Tetchldibenz-p-diox